The Journal
OF THE
Royal United Service Institution.

VOL. XIII. 1869. No. LV.

LECTURE.

Friday, March 19th, 1869.

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SUMMARY OF THE EXPERIMENTS AT SHOEBURYNESS DURING THE YEAR 1868-9.

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IT would hardly suffice in a *résumé*, such as I am now attempting, to follow the experiments seriatim, in the order of their dates, but it will be preferable to classify them into groups of subjects, so that the sequence of the results may be the better understood and comprehended. These sections, then, will be:—

I, Heavy Artillery; II, Ammunition; III, Field Artillery; IV, Iron and other Defences; V, Chemical and Incidental.

The tendency of gun-manufacture has been in the direction of larger and more powerful rifled-guns, and with the accomplishment of successively enlarged designs, has increased the difficulty and delay in moving and training these increasingly ponderous, offensive machines. The 9-inch gun is perhaps the largest that as yet can be satisfactorily worked with sufficient rapidity; with guns above that capacity, the great force of the recoil from the enormous charges of powder used, and the momentum of such masses of metal thus put in motion, had become elements of extreme difficulty. The necessity for carefully protecting these costly guns and their stores, as well as the specially trained men detached for serving them in action, has caused the smallest possible dimensions of port-hole to be most in favour, notwithstanding that the small-port-system does incur difficulties in sighting, and the absolute necessity for bodily lifting or lowering the gun in working and training. The enormous power of modern artillery has demanded

shields and casemates of iron of a resistive capacity unheard of up to the present day. Mechanical skill has thus been necessarily required to aid both practical works of offence and defence; whilst the accuracy of fire has become too precise to permit any longer of open embrasures in the earthworks or masonry of ordinary fortifications. The value of chemistry, too, has been recognised in tests of the condition of stores, signal lights, and new and most powerful explosive-compounds. Such are only the main elements of the 40 days of experimental labour, and of the 220 separate sets of experiments which I have to reduce to order and pass under review within the one hour allowed me here to-day.

I pass then at once to the heavy artillery practice and trials, with the carriages of various natures tested in connection therewith; the means adopted for overcoming recoil; the mechanical appliances produced to facilitate convenience and rapidity of handling, in fact all that is immediately connected with heavy guns, assuming the 9-inch 12-ton Woolwich gun adopted into the service, as being the previous general limit of heavy rifled ordnance.

I.—Heavy Artillery.

§ 1. *Guns.*

The 10-inch rifled muzzle-loading Woolwich gun was tried on the 15th February. Its length over all is 15 feet 4 inches; of bore 145·75 inches; rifling seven grooves 1·5inch wide and 0·22 inch deep, spiral, one turn in 100 calibres at breech, increasing to one in 40 at the muzzle. Its weight is 18 tons 2 qrs. 4 lbs., and the breach preponderance 1 cwt. 2 qrs. 10 lbs. The practice was made at three degrees elevation, with eleven rounds of Palliser shot, 1·25 ogival head, and 400 lbs. weight; with ten Palliser shells, 1·5 ogival head, weighing, empty, 390 lbs., and containing bursting charge of 10 lbs., making a total weight of 400 lbs.; and with ten common shells, 1·5 heads, weighing, empty, 368 lbs., and containing bursting charge of 32 lbs. = 400 lbs. The charge for the gun used with the shot was 60 lbs. l. g. r. powder; for the Palliser shells 64 lbs. of pellet powder; for the common shells 40 lbs. l. g. r. powder. The results of the practice were excellent. With the shot, the range was from 1,592 yards to 1,725 yards, the deflection, all to right, from 3·6 yards to 8·4 yards. With the Palliser shells, the range was from 1,651 to 1,778 yards, time of flight from 4·4 to 4·7 seconds, and the deflection, all to the right, from 1 yard to 5·6 yards. With the common shells, range from 1,295 to 1,396 yards, time of flight from 3·8 to 4·1 seconds, deflection to the right 0·4 to 3·2 yards. The gun was worked by a detachment of one sergeant and fourteen gunners. Further practice was made with this gun on the 5th of March.

On the same day (15th February) trials for range and accuracy of a 12-inch rifled muzzle-loading Woolwich gun, of the jacketed pattern, were begun. The dimensions of this gun are:—length, 12 feet 1 inch; rifling 127 inches, with 9 grooves 1·5 broad and 0·2 inch deep,

the spiral increasing from one turn in 100 calibres to one in 50 at the muzzle. Weight 23 tons 6 cwt. 1 qr. 26 lbs.; no preponderance at the breech. The practice was made with 600-pounder Palliser shells, with charges of 70 lbs. of pellet-powder. The flight of the projectile at 10 degrees of elevation of gun, was 12·5 to 12·6 seconds.

Further testing of this 12-inch gun was made on the 5th December, the wrought iron carriage and platform being mounted on C racers. This carriage and platform are part of the supply for Malta. The shot used in the practice, were Palliser-cored of 600 lbs.; the gun charges 70 lbs. r. l. g. powder. The tide having covered the foreshore, the exact range and accuracy of the shot could not be obtained, but the practise made in two rounds at a floating target about 1,800 yards distant, was very good.

An 11-inch bore muzzle-loading rifled wrought-iron 530-pounder gun was also tried in September. Weight 22 tons 3 cwt. 2 qrs.; breech preponderance 14 cwt. 1 qr. 8 lbs., length of bore 145·0 inches, over all, 180·0 inches; rifling, Woolwich system, rounded groove, spiral increasing from one turn in 100 calibres to one turn in 45 calibres at muzzle, seven grooves, width 1·50 inch, depth 0·22 inch, length 120 inches. It was decided to use pellet-powder in this trial, and the first step, therefore, was to ascertain the proper equivalent charge to 50 lbs. and 70 lbs. of l. g. r. powder. After firing the 17 rounds, and taking the initial velocities, it was decided that 54 lbs. and 78 lbs. were the equivalents respectively of the service and battering charges. The trial for range and accuracy was begun with common shells, 1·5 diameter ogival heads of the mean weight, empty, of 489 lbs., bursting charge 40 lbs., total 529 lbs.; length 37·6 inches, windage 0·08 inch. The range got with 54 lbs. charges, at 3 degrees elevation, was from 1,189 to 1,232 yards, the shells proving very unsteady in flight. Increased charges of 65 lbs. were fired, to see if the shells would prove steadier at a higher velocity; 1,410 yards were attained, but no improvement in the steadiness of the projectile. Next, a Palliser-cored-shot, 1·25 diameter ogival head, mean weight 534½ lbs., length 26·2 inches, was fired. At 3 degrees elevation the practice made with 78 lbs. powder, was from 1,570 to 1,673 yards.

I now come, in the sequence of events, to the system of conversion and construction of compound guns proposed by Mr. Parsons. And in describing that gentleman's plan, I shall endeavour to express his views as accurately as possible, and this will be the more just to him, because individually I am adverse to any conversion of cast-iron guns at all, although I have no desire whatever to do other than recognize the merits of Mr. Parsons' plan in respect to the construction of new weapons.

Mr. Parsons' attention was directed to the subject about the year 1858-9, when great efforts were being made by the Government to utilize, as it has been commonly termed, the cast-iron service guns, by strengthening them with external hoops of wrought-iron. Mr. Parsons formed the conclusion that this plan was the reverse of what theory indicated, if two metals possessing different degrees of elasticity and extensibility were to be combined effectually, and he consequently

proposed his system of strengthening cast-iron guns by lining them with wrought-iron or steel-tubes, submitting this plan in May, 1860, to the Government. He then proposed to bore out the gun cylindrically, or slightly conical, and to force into it, by mechanical pressure, a tube of wrought-iron, or steel, turned accurately to fit the interior of the cast-iron casing. A drawing of a 68-pounder, lined with wrought-iron or steel tube, was sent to the Secretary of State for War at that date.

Mr. Parsons' argument was this:—

It is the interior of the gun that sustains the greatest shock; if this is of cast-iron, it is strained beyond its elastic limit before the strength of the hoops comes into play, but if the interior is of wrought-iron, steel, or homogeneous metal, it will stretch before breaking, but the stretching consumes a large portion of the force, and the remainder only is transmitted to the cast-iron, and is imparted to it in a less sudden and equable manner; the cast-iron, in fact, has only to do surplus duty. Another important feature in this system is that the longitudinal strength of the gun is not impaired as it is when the breech is turned down to receive external hoops. Mr. Parsons, after this, applied for a patent in 1860 for the use of a second, or B-tube, surrounding the A-tube, and in some cases, for very large guns, he proposed to use a third tube, surrounding the second, or B-tube, the lining tube thus built up being inserted into the cast-iron casing, as before. In 1861 the Ordnance Select Committee had a 68-pounder strengthened on the plan proposed by Mr. Parsons, but the inventor was not employed to carry it out, and the work was not, in consequence, done so effectually as it would have been, had he been consulted. The tube was bored out of a solid block of wrought-iron, which method he did not approve, and the thickness of the tube he proposed was about one-third more in proportion to the calibre than the one employed. Nevertheless, the Ordnance Select Committee report of this gun that "it endured 71 rounds proof series," *i.e.*, with a charge of 16 lbs. and shot of 68 lbs. increased every ten rounds by its own weight, the weight of the shot at the 71st round being 476 lbs., "that this exceeds in endurance all but one of the 68-pounders ever "tested, and all the 68-pounders strengthened externally by hoops." A second gun on Mr. Parsons' plan, a 32-pounder lined with a coiled wrought-iron tube, was tested in 1862, and the Ordnance Select Committee report "this gun endured 74 rounds (proof series), the unit "charge being 10 lbs. powder and a shot of 31·5 lbs.; this gun "did not burst, but the lining tube became flawed."

In June, 1862, Mr. Parsons patented an improved plan of inserting the tube into the gun, the object being to obtain a tube of larger diameter at the breech-end than would admit of being passed through the muzzle, he having become convinced that to retain a calibre suited to the weight of gun, sufficient strength to make the guns efficient rifles could only be obtained by this increased diameter. This he effected by boring out the gun from its breech-end, and inserting a reinforced tube through the breech and securing it in the gun by a breech-screw, screwed in behind it.

This method of inserting the tube from the breech end was submitted to the War Office in 1863, but was not accepted by the Ordnance Select Committee. The year following, a 30-pounder gun was converted by the French Government into a 6·5-inch rifled 100-pounder of 64 cwt., and tested at Gâvre. It fired 510 rounds, with 8·82 lbs. powder, and 69·43 lbs. shot, and 500 rounds with 16·54 lbs. powder, and 100·22 lbs. shot, in all 1,010 rounds, the gun still being serviceable. Subsequently it was fired with 26½ lbs. powder, and cylinders of 132 lbs. At the 1,021st round, it split in the chase, the breech re-inforce and breech-screw remaining perfectly sound.

After this, Major Palliser's plan of conversion received attention from the authorities, and it was not until the end of 1867, on the motion of Lord Elcho in the House of Commons, and the compliance of the Secretary of State for War, that Mr. Parsons' strengthened gun again appears upon the scene.

This gun, ordered in November, 1867, was delivered in August, 1868, and tried at Shoeburyness on the 10th September. The inventor had challenged to fire it with 30lb. charges, and 150lb. projectiles; and he boldly put the vent in the service position. The gun was proved at Woolwich with two rounds of 37½lbs. powder, and 150lb. shot, a rather stronger dose than the inventor anticipated, and which, as he believes now, overstrained the gun, and diminished its ultimate endurance. It, however, endured 163 more rounds, with charges of 30lbs. of powder and 150lbs. shot, when the outside-casing cracked, and on inspection, the B-tube was also found to have split, but the A-tube was sound and serviceable.

The gun was rifled with three raised ribs, having a uniform spiral of 1 turn in 30 calibres or 20 feet; the vent was placed 8 inches from the end of the bore. This rapid rate of twist gave a high amount of spin, whilst the cartridge being ignited near the middle, imparted to the projectile a very high velocity, and the ranges consequently attained by this gun were very long, surpassing, I believe, those of the service guns at corresponding elevations.

The mean ranges were:—At 1° 20′, shot 932 yards, shell 912 yards; at 3° 10′, shot 1,921 yards, shell 1,965 yards; at 5° 7′, shot 2,792 yards, shell 2,826 yards; at 7° 5′, shot 3,538 yards, shell 3,667 yards; at 9° 4′, shot 4,232 yards, shell 4,381 yards; at 19° 3′, shot 6,715 yards, shell 7,092; the longest range attained at 19° 3′ being 7,300 yards.

The weight of this 64-pounder gun as converted, is 103 cwt., calibre 8 inches, length of bore 131 inches.

When it is considered that this gun is of the same calibre as the service guns of 9 tons weight, made entirely of wrought iron and steel, and that it has fired continuously the full battering charges of those guns, the endurance exhibited is extraordinary; perhaps, however, the most valuable feature that the system, by this experiment appears to possess, is, freedom from explosive bursting. There is no instance, so far as I know, on record, of any gun firing continuously such heavy charges in proportion to its weight.

This gun yielded harmlessly. Its failing was indicated clearly

by an external sign to those around, and their safety thereby secured.

Mr. Parsons considers this not the effect of accident, but that the same result must follow as a consequence, so long as the two materials used, retain their respective qualities.

It is known that good mild steel will stretch from 15 to 20 per cent. of its length, before it breaks, and 5 per cent. before its tenacity is impaired; but the very finest cast iron will not stretch 5 per cent. It is evident, therefore, that if the whole structure is of sufficient strength to resist bursting explosively at the proof, it can only afterwards fail by the gradual stretching of the inner tube, and that long before it has gone to a dangerous extent, it must split open the cast iron casing.

Next follows a most important weapon—the Whitworth gun.

The Whitworth 9-inch rifled muzzle-loading steel gun is, in fact, a 310-pounder. Its weight is 14 tons 8 cwt., the breech preponderance 6½ cwt. 20 lbs.; length over all, 163·80 inches; of bore, 140·06 inches; calibre major axis, 9·025 inches; minor axis, 8·250 inches; rifling Whitworth's hexagonal, spiral, uniform, one turn in 171 inches. The vent horizontal, through the cascable in line of axis of the gun, the hole being covered with a metal tube-catcher for naval service. The construction is on the built-up system, the inner tube being of Firth's steel, the same as in the Woolwich guns. This is covered over by a second steel tube, over the rear portion of which is a steel jacket. Over this again are two jackets of Whitworth metal, or steel compressed by hydraulic pressure. The shape of the gun is good, and the metal so far has acted up thoroughly to the heavy duty required of it. The first practice was made on the 15th and 16th September.

After firing seven rounds, it was tested by Mr. Whitworth's machine (which gauges to the $\frac{1}{10000}$th part of an inch) for the detection of the slightest enlargement of the bore or any permanent set. Mr. Whitworth properly considering that the first sign of the yielding of the metal, marks the commencement of the destruction of the gun; and these delicate testings enable the immediate determination of the maximum charge to which the gun could be exposed without injury. The measurements showed a set of $\frac{1}{2000}$th of an inch at the extreme rear-end of the chamber; of $\frac{1}{7000}$th at the front of the chamber, and thence to the muzzle there was absolutely no difference after the firing. This exceedingly minute difference may be readily accounted for by the wear, or by the compression of the mass of metal; and there really was in fact no actual distension of the bore. The projectiles are of hexagon shape and spiral to follow the rifling of the gun, having a windage over the major axis of 0·065 inch, and over the minor axis of 0·070 inch.

Those provided for this experiment were:—1. Common shells with parallel rears, weight 290½lbs. empty; bursting charge, 18lbs.; length, 31·6 inches; diameter, major axis, 8·96 inches; minor axis, 8·18 inches. 2. Common shells with taper rears, 285lbs. empty; same length and diameter, and bursting charge. All were filled with sand to 310 lbs. weight in the practise. 3. Hollow shot with taper rear 249 lbs.;

24·7 inches long; diameters, 8·96 and 8·18 inches. The cartridges were made on a peculiar plan, devised by Mr. Whitworth, so that the powder might be ignited well towards the front. Through the centre was passed a thin copper tube, perforated with numerous holes, over half its length. Into this, at one end, is inserted a small funnel-shaped primer cartridge, containing 120 grains of powder, the object of which is to ignite the charge of the gun rapidly, and to begin to move the projectile before the great explosion takes place. Disc papier-mâché wads, 18ozs. in weight, fitting the bore, were used. The practice with the gun could only be made at extreme low tide, on account of the great length of the range. The experiments carried out were of a two-fold character; firstly, to ascertain the suitable charge for the gun; secondly, the difference of range between shells of 310lbs. weight with parallel *versus* taper ends, and hollow shot of 250 lbs. having taper ends; and thirdly, the difference of effect between Mr. Whitworth's tubular cartridges and solid cartridges ignited at the centre of their length. In the following tables of practise, only the rounds giving maximum ranges are entered:—

Projectile.	Weight.	Cartridge Charge.	Elevation of gun.	Flight. Seconds.	Range. Yards.	Deflection. Yards.
Common Shell, Parallel Rear...	310 lbs.	tubular 45 lbs.	... 10°	13·6	4756	36 right.
,,	310 lbs.	tubular 50 lbs.	... 10°	13·7	4905	35·4 right.
,,	310 lbs.	tubular 55 lbs.	... 10°	14·3	5089	26·4 right.
Common Shell, Taper rear ...	310 lbs.	tubular 55 lbs.	... 10°	13·7	4910	14·0 right.

Of a further trial which was made on the 23rd November: first, to ascertain the difference in range between hollow shot of 250lbs., and common shells of 310lbs. weight, with parallel rears, and Mr. Whitworth's tubular cartridges for gun charges.

Series.	Projectile.	Flight.	Charge and Cartridge.	Elevation.	Range.	Yards in Deflection.	
		Seconds.		Degrees.	Yards.	Right.	Left.
1 ..	Shell, 310 lbs. ..	13·5 ..	50 lbs. tubular ..	10 ..	4,868 ..	—	1·0
2 ..	Shot, 250 lbs.	14·2	50 lbs. tubular ..	10 ..	5,169 ..	7·0	—
3 ..	Shell, 310 lbs. ..	12·1 ..	50 lbs. solid ..	10 ..	4,021 ..	6·2	—
4 ..	Shot, 250 lbs.	not observed.	50 lbs. tubular ..	33	above 10,300 ..	not taken.	

Further practise, namely three rounds, was made on the following day, at the same high angle of elevation, to attain which, the wood-platform, on which the gun was mounted, was tilted up in front to the required height, and the gun-carriage strapped on by stout breeching-ropes. The following are the details of these extraordinary rounds:—

Round.	Projectile.	Flight.	Charge and Cartridge.	Elevation in Degrees.	Range in Yds.	Deflection in Yds.
5 ..	Hollow Shot, 250 lbs. ..	Not Seen ..	50 lbs. tubular ..	33° ..	11·243..	400 about
6 ..	Common Shell, 310 lbs. ..		50 lbs. tubular ..	33° ..	11·075..	500
7 ..	Common Shell, 310 lbs. ..		50 lbs. tubular ..	33°·5..	11·127..	385

The high elevation of the platform in this temporary manner necessitated, of course, the laying of the gun by the same method as is practised for mortars, actual sighting not being possible.

One instance of a very heavy gun having been fired in actual warfare at such a high elevation, is on record in the "Professional Papers of the Corps of Engineers," No. 14, 1868, in the article "On Siege Artillery in the campaigns against Richmond, with notes on the 15-inch gun," by Brigadier-General Abbot, U. S. Army.

Further trials of the Whitworth gun were made on the 11th December. With 40lb. gun charges, the shells made from 4,602 to 4,650 yards, the shot 4,547 to 4,978 yards; with 50lb. charges the shells made 5,066 to 5,131 yards, the shot 5,426 to 5,480 yards, with tubular cartridges. With 50lb. charges, solid cartridges, the shells made from 4,206 to 4,438 yards. All the rounds were at 10 degrees elevation; and the projectiles had parallel rears.

Next follows a gun from which much was hoped for, and may even yet be realized. The 10 inch m. l. r. gun, on Mr. Charles Lancaster's semi-oval-bore system, which had its first final trial on the 26th October. Its details are:—weight 18 tons 1 cwt. 1 qr. 20 lbs.; breech preponderance 7 cwt. 2 qrs. 16 lbs.; bore, semi-oval, the lower part at muzzle circular; calibre major axis 9·85 inches, minor axis 9·75 inches, spiral uniform one turn in 255 inches; length of rifling 127·5 inches, or half a turn actual in the twist of the gun. The projectiles were perfectly cylindrical, with ogival heads of 1·5 diameter, and with rear-ends of the body tapered off for about an inch. On the base were raised flat star-like rays for the bite of the wad or sabot from which the rotation of the shot is expected to be obtained; length of shot 26·85 inches, weight 400 lbs. The wads were of papier-mâché, in weight 7½ lbs. Ten rounds were fired, but all the shot wobbled from want of spin. It is but fair to the inventor, however, to state that his intention was to have had greater twist in the rifling of the gun, but the first cut having been made before he was aware of it at this very slow pitch, he allowed it to go on for trial. There is enough metal to spare to re-rifle it upon this system, taking the present major diameter for the future minor diameter, and after that the gun could still be rifled out a third time upon the Woolwich service pattern. It seems to me that the twist of the rifling should be very quick in so near an approach to a smooth-bore, to cover the probable amount of slip in the wad over the surface of the bore whilst overcoming the inertia of so heavy a mass as a 400-pounder projectile.

§ 2. *Appliances.*

The working and training of very heavy guns, a matter of the highest importance, has made considerable advance during the past year.

A very interesting part of the experimental trial of the 12-ton gun on the 15th February, was the application of Colonel Inglis's turntable, and of Mr. Cunningham's gearing. The turntable was intended to traverse a gun from one to the other of two contiguous embrasures,

and, in addition to its rotary horizontal motion around its own centre, there were laid down upon its floor, arc-racers for the moving over of the carriage.

Mr. Cunningham's gear is an iron chain fastened at opposite sides on the platform, and passing over a pulley-wheel indented with sockets for the chain-links, the chain being held tightly down by rollers on each side, at a lower level than the summit of the pulley wheel, and being kept in its course by guides. This was its first practical application.

The gun was served by a detachment of one officer, one sergeant, one corporal, and eighteen gunners, many of whom were untrained men. It was variously shifted and fired through one or other of the two ports of a wooden model-casemate, the extreme traverse of the gun by the turntable through 120° of range, being accomplished in 1 minute 15 seconds, and the transfer of the line of the gun from one port to the other, in 25 seconds.

Mr. Cunningham's most convenient gripping-barrow for running heavy projectiles up to the gun, and his over-head railway for raising heavy shot and shell conveniently up to the muzzle for loading, were also used with highly satisfactory results.

This 600-pounder gun in the first instance had no other means for traversing on the table than the ordinary shod levers and tackles. The labour and loss of time in traversing by these primitive means, were very great; not less than 20 men on the tackles, and two men on the shod-levers, were required to move the gun. For training or rather laying the gun when a reciprocating movement had to be obtained, the men on the one side had to pass over as fast as possible to the other side to pull the gun round the contrary way in which they had been already pulling. As an equal number of men were required on both sides, it was not only the number of gunners employed merely for training, that constituted the evil, but the great exposure also to which these men were subjected from shot entering the embrasures or ports. Another serious embarrassment was felt in the confined space within which the men worked, especially when the gun was trained extreme, it being then almost impossible to work at all. It must also be borne in mind that when great manual power is applied by crude mechanical means, there is a want of that nicety in the application of it so necessary for laying an arm of precision, and the largest of our guns may properly so be viewed. There is a spasmodic kind of action in the effort of men which it is well known on the old system of training results in the gun being probably pulled too much on one side and beyond the object, when power has to be applied on the other side to bring the gun back again. These considerations, of course, do not refer to guns mounted on revolving platforms solely, but to guns in any position, and as regards want of space, especially to guns in casemates. This is a very serious matter when it is required to follow fast steamers. Soon after the gun was mounted on Colonel Inglis's iron table, Mr. Cunningham was requested by the War Department to apply his training gear to it; this was done in a very short time, the striking advantage in the Cunningham system being that it can be ap-

plied to guns in position without the necessity for removing the platforms to a factory to be fitted, so in this case the Cunningham gear was sent down and the ordinary artificers in the establishment at Shoeburyness had no difficulty in applying it to the platform. The result was very good. It was found that two men could traverse the gun with great precision, and could move it round from the extremes of training in 90 seconds, the distance traversed by the rear of the platform being 28 feet. This result was obtained with a crank handle. Mr. Cunningham at first turned by a hand-wheel, but the motion was slow, and he abandoned it for the common winch. It may be probably as well to note, that as by the action of the pinion and power-wheels, the chain is drawn in on one side and passed out on the other, it forms as it were a flexible-cogged-rail, and thus in whatever direction the winch is turned, the gun is drawn, and a reversion of the winch-handle, produces a reciprocating movement in the gun. Practically it was found necessary to take up the slack of the chain when the gun was trained extreme, as it will be observed that the chain in this position represents in measure-value only the chord of the circle described by the rear of the platform, the difference, therefore, between the measure of the chord and that of the circle, represents the amount of slack chain. To rectify this Mr. Cunningham at first applied a block and tackle with a snatch-hook, but he found that by merely placing stop-bolts, or snatch-bolts, as they are technically called, a little within the arc of the circle described by the rear of the platform, the chain laid itself over these bolts on one side as the platform revolved and took itself off on the other. An important practical point was thus obtained, as by an adjustment of the number of these snatch-bolts, any amount of tension of the chain can be got, and any amount of revolving distance obtained, short only by a few degrees of the actual circle.

A 25-ton gun, mounted on a fixed platform, furnished with a central pivot, has lately been fitted by Mr. Cunningham at Shoeburyness. The snatch-bolts in this case are so arranged that the gun can be trained upwards of 350°. It may be interesting in this place to notice another form in which this system has been applied, that of a 23-ton gun mounted at the new battery at Southsea Castle, fitted to traverse 90°, which gives it a complete command of the Channel going into Portsmouth Harbour. This gun was fitted by Mr. Cunningham about three years ago, and although all that time exposed to the weather and frequently to the wash of the sea-water, it is in perfect working order. In December last, on the occasion of the visit of the Defence Committee, a fast steam pinnace was caused to pass backwards and forwards in the Channel to test the training powers of the gear. When going down with the tide at a rate of say nine knots, and at a distance within 200 yards, two men moved the gun round, keeping ahead of the pinnace with perfect ease, and with a considerable amount of speed to spare. One man also traversed the gun. The men who traversed, were completely under cover of the gun and protected from shot. No. 1 man is also so covered that practically he is protected from hostile shot. The important fact then which has been obtained

in the Cunningham system is, that our largest guns can be trained by two men, and these under cover of the gun. Thus, after the weapon has been loaded, all the detachment, except No. 1 and the traversing and elevating numbers, can retire under cover, whereas before, it was in training the piece that all the detachment necessarily remained exposed to the enemy's shot. The advantages obtained by this system are, therefore, unquestionably important.

Mr. Cunningham has also had in view the importance of putting the shot into the gun with as few men as possible, so as to avoid the severe labour, as well as the exposure which men are exposed to at the port in loading. Amongst the several simple provisions for saving labour, and especially for applying strength in the more favourable manners for saving muscular strain in lifting and travelling heavy weights, points in modern gunnery practice not considered so much as they should be, is the over-head railway to which I have referred. Upon this rail the projectile is conveyed to the gun by a carriage formed to travel on the rail, the projectile having been previously lifted by pulley-power to a proper level for putting into the bore. His shot-carriage for running up shot from a magazine to the gun is also an ingenious and useful affair. The over-head rail can be of course carried to any distance, and by it projectiles can be lifted from the shell-room or shot-pile in the rear or near by, and conveyed at once to the muzzle of the gun. The manual shot-lift, or bearer, designed by Mr. Cunningham is a simple and very useful instrument. The result of Mr. Cunningham's arrangements with the 23-ton gun at Shoeburyness, was that one man lifted the 600-pounder shot on the carriage, and with the help of another man conveyed it to the shot rail. Two men hoisted it up and conveyed it along the rail to the muzzle, where it was landed on a muzzle roller-bearer, and easily shoved into the gun. By the removal of the studs from the extreme base of the projectiles this roller-bearer is not required, and the shot is put directly into the gun.

Those who have witnessed the struggles and dangerous efforts of some 30 or 40 men in loading and working these huge weapons, can well appreciate the value of the relief from the unavoidable confusion and inconvenience incidental to the action of such a crowd within a very restricted space, and can equally comprehend the superior telling effect in an actual conflict, of a few men working quietly and smoothly with well-applied mechanical contrivances. In fact, it is impossible to ignore the absolute necessity for powerful mechanical means for handling with facility such enormous weights as the ever-increasing dimensions of modern cannon are bringing upon artillerymen, for in the absence of such means, the values of long range and immensely destructive projectiles will be largely deteriorated, if not actually out-balanced, by the inert intervals between the rounds in the firing. The results of this trial completely clear all fears of difficulties in the practical use of ordnance of increased size and power, whilst the success was such as must cause an extensive introduction of mechanical means in aid of human labour in defending permanent fortifications.

I come now to the subject of muzzle-pivoting guns. There can be no two opinions as to the value of some class of muzzle-pivoting for casemate and ship's guns; for not only does the small port-hole prevent the enemy from pitting in his rifle bullets, as well as diminish to a minimum the ingress of langridge through the opening, but the small port-hole is an advantage not to be overrated in adding to the strength and resistance of the iron shield or casemate-wall defending the gun. In cupola-ships the need for muzzle-pivoting is greater even than in land defences. The necessarily slow action of training heavy guns, where the whole weight has to be bodily lifted, is, however, a serious drawback to the practical value of the muzzle-pivoting system in any guise. Three systems in this direction were tried during the past year—Colonels Clerk's, Shaw's, and Inglis's.

Colonel Clerk's supports the chase of the gun at the pivoting point on the carriage, at which point, levers on either side find a fulcrum to lift the body of the gun. The shock of the recoil is taken on the levers.

Colonel Shaw's muzzle-pivoting gun carriage has been tried on board the "Royal Albert" for the 12-ton gun, and is already described in the "Journal" of this Institution.* The rear-portion of the gun is worked, as you well know, by rack and pinion and screw-motions in connection with two pairs of arcs on the sides of the carriage, the front-pair being of proportionately smaller radius than the hind-pair. The carriage tried in October last at Shoeburyness is for a 10-inch, 18-ton, 400-pounder gun; and the high charges of 60 lbs. of powder bring enormous strains upon the various parts. In the practice made on this occasion, the detachment working the gun, consisted of one sergeant and fourteen gunners; the number of men at each winch-handle to depress the gun was three; to elevate it, one. To ascertain the time required for extreme depression and elevation, trials were made with these results:—Gun at 3 degrees; to bring it back to zero, or level, 1 minute 5 seconds; depressing from zero to $4\frac{1}{2}$ degrees, 1 minute 35 seconds; total time required to depress from 3 degrees of elevation to $4\frac{1}{2}$ degrees of depression, that is, through $7\frac{1}{2}$ degrees, 2 minutes 40 seconds; time to elevate from $4\frac{1}{2}$ degrees of depression to 3 degrees of elevation, that is, to elevate through $7\frac{1}{2}$ degrees, 2 minutes 40 seconds. Several rounds with 60lbs. charges were fired from the 10-inch gun mounted on this carriage at 2,000 yards range. Every shot struck close to the target; this remarkable accuracy being due to the clamping of the gun in position, so that the angle of elevation is never disturbed by the recoil, and any number of rounds can be fired without re-adjustment of elevation.

Colonel Inglis's carriage differs materially in principle from all others that have been proposed, namely, in this respect, that the gun is not made to move for elevation and depression about a fixed point at the muzzle, but is mounted on its trunnions in the ordinary way. Only, as the port admits of but small movement of the muzzle about any one centre, the position of the trunnions has occasionally to be

* Vol. ix., page 446.

raised or lowered, to gain room for greater depression or elevation; so that, instead of having to deal with the whole weight of the gun for each change of elevation, as in other methods, here, within certain limits, the preponderance only has to be dealt with. When those limits have to be passed, the gun must be lifted, or lowered, bodily into another position, where, within similar limits, it will work on its trunnions, as before. By this arrangement the port can be reduced, so that for an 18-ton gun, with its sights 20 inches apart, and 22½ inches above the axis of the bore (the positions, I believe, settled upon for the sights of this gun,) an elevation of 10 degrees, a depression of 5 degrees, and a lateral training of 70 degrees can be got within a port measuring externally 2 feet 9¾ inches in height, and 2 feet 5 inches in width. If, by placing the sights of the gun on its chase, or by any other expedient, the sight-line can be brought nearer to the axis, then the dimensions of the port as to height can be still further reduced. It is calculated that four men on each handle will be able to raise the gun through a space equivalent to 1 degree of elevation in about half a minute. An indicator is fixed on the side of the carriage to denote at all times the position of the trunnions, and the corresponding degrees of elevation obtainable through the port. The carriage runs on ten rollers, the object being to facilitate the working of the gun. The slope of the platform is reduced to 3°, a steeper incline being thought objectionable with the great weight of this gun and carriage.

The very great and important innovation in the arrangements for checking recoil which has been introduced by Colonel Clerk, R.A., the Superintendent of the Carriage Department at the Royal Arsenal, has had during the various trials of heavy ordnance carriages, trying tests which have satisfactorily proved its value, and certainly of practical action. The principle is that of a perforated piston, working in a cylinder of water or other fluid; the gun-carriage is attached to the piston-rod, and by the action of the recoil, the piston is forced back against the water which escapes through the perforations (which in the experimental hydraulic compressors employed, were four in number) the friction and resistance absorbing the momentum of the gun, and bringing the carriage up within the variation of an inch for any number of rounds with the same charges. The length of recoil is modified by the quantity of water in the cylinder. Colonel Clerk is carrying out experiments to give the exact curves of resistances and other philosophical details; and is also applying the system to the buffers of railway engines and trains, with a view to the prevention of the serious effects of collisions.

I cannot permit myself to conclude this review of the first portion of my lecture without acknowledging the value of the system of tempering steel tubes in oil, introduced practically into the Arsenal, I believe, by Mr. Anderson; nor would I omit to make one observation on the important development of future heavy guns through the researches upon the actual condition of the expansive force of gunpowder within the chamber of the gun itself.

It would be premature to announce decided conclusions as to the relative pressures of rifle-large-grain powder *versus* pellet-powder, in the

present stage of the inquiry, as the experiments by the Committee on Explosive Substances have been so far made with a 2-inch gun, and although the pressure with pellet-powder was much less in this calibre, it cannot be certainly said what it may be found to be in a 9-inch gun. But I may say that the preliminary trials have shown that the pressure given by rifle-large-grain powder is very violent, and reaches a maximum in a rifled-gun after the projectile has moved about half a calibre. With pellet-powder, on the contrary, the pressure is not nearly so great, and there does not appear to be that intense local effect which characterizes the explosion of rifle-large-grain powder. The pellet-powder-pressure is much more uniformly distributed along the bore.

II.—Ammunition.

In this group a variety of questions respecting ammunition, shells, fuzes, case-shot, rockets, are brought under experimental resolution.

The question of the suitability of some qualities of the dockyard-ballast, known familiarly as "Seely's pigs," for the manufacture of Palliser-chilled-projectiles, received elucidation by a small number of projectiles supplied by Sir W. Armstrong for the service 7-inch muzzle-loading-rifled-gun fired against a 10-inch plate by Brown, of Sheffield, at 70 yards, with 22 lbs. l. g. r. p. charges. The results indicated a percentage in favour of the superior qualities of the service chilled-shot.

Questions having been raised as to the accuracy of flight of the Palliser-projectiles, a programme was arranged with a view to compare them with ordinary rifle shot and shells, and with round shot, and, by firing at a target of considerable size, to ascertain whether any difference did exist of a character to qualify their employment against vessels-of-war at moderate distances. The guns in position for this purpose were:—one 9-inch 12-ton muzzle-loading Woolwich rifled gun, one 7-inch 7-ton similar gun, one 40-pounder 35-cwt. breech-loader rifled Armstrong pattern gun, and one 68-pounder 95-cwt. smooth-bore cast-iron gun. The target was of canvas, 40 feet square, and divided across into squares of 5 feet each, a black bull's eye, 4 feet by 2 feet 10 inches, the size of the port-hole of an iron-clad ship, being painted in the centre. The distance of target from gun 1,000 yards.

With the 9-inch m. l. rifled gun, with shells, but with reduced charges of 32 lbs. l. g. r. powder, the results obtained were extraordinarily excellent. Three shots passed through the bull's eye; three others all but touched its right edge; and three others were within the squares upon which the bull's eye was painted, all the nine being within the inner square of 10 feet covering the centre of the target. The tenth hit carried away one of the supporting poles, and brought down the target, the practice being thus also brought to an end.

Experiments to ascertain the cause of the premature bursting of shells,

were made in February, and a continuation of these trials was carried on in March, the object being to ascertain whether the premature bursting of the shells is traceable to some action of the bursting charge, or whether it may be traceable to any action of the fuze.

The Dyer or C percussion-fuze so extensively employed in the service having been found liable to premature action, two plans were proposed for the improvement of the large quantity in store. One by Sir William Armstrong, namely, the putting a leaden-ring in the bottom of the pellet to cushion it and prevent rebound when the suspending-pins are sheared on the discharge of the gun; the defect being that the pellet frequently falls with sufficient force to rebound and strike the needle, exploding the shell at the muzzle. The other, or Mr. Pettman's plan, remedies the premature explosion of the fuzes by placing a thin leaden-cup between the pellet and the bottom of the case. The pellet falling on this cup flattens it down to a disc, and the rebound is completely prevented. The great advantage of the Pettman plan is, that the alteration can be made at any station, by simply opening the fuze case and dropping in the leaden-cup; there is no need to send the fuzes to the factory for operation, as would be the case with the Armstrong method. Mr. Pettman's system was tested with 100 rounds of segment-shells, 50 from a 12-pounder, and 50 from a 9-pounder breech-loading-field-gun, with most satisfactory results. The plan has been officially adopted. The carrying out of this order has, however, been suspended.

In consequence of a recent order that all common shells should be carried loaded in the ammunition boxes of field brigades of artillery, it became necessary to devise some plan to prevent the powder in the shells from working up into the metal-socket or receptacle in which the C percussion-fuze is placed, and the plan proposed was, to close the hole in the socket by a papier-mâché wad. Then arose the question as to whether the explosion of E time or C percussion-fuzes was sufficient to blow into the shell the papier-mâché wad, and thereby ignite the bursting charge. Experiments in connection with this subject had been previously made, but in consequence of two shells not having exploded during those trials, it was considered advisable to repeat the tests.

The practice clearly showed that the fire of the fuze was sufficient to blow in the wad closing the shell-hole, and that the failures were due to the fuzes, which were not satisfactory; 32 per cent. of the time, and 8 per cent. of the percussion-fuzes, not having acted.

A third series of experiments in connection with the subject of the non-ignition of fuzes was made in continuation of the practice on the 19th of August and 17th April, to ascertain whether Colonel Boxer's 9 seconds wooden-time-fuzes for rifled guns would light in common shells specially lead-coated, as prepared to be fired with 9 lb. charges from a 64-pounder Armstrong wedge-breech-loading gun.

The practice with Colonel Inglis's gun-carriage on the 28th November was utilized in trying the 10-inch Boxer-Shrapnel shells, with a view to ascertain if these missiles were strong enough to stand the charges used, and at the same time to test the times of burning of the 9 seconds-wooden-fuzes. These shells are 32·2 inches long; and contain

450, 4-ounce iron shot, cast in sand, and a bursting charge of 16 ounces of fine grained powder; weight loaded, 388 lbs. They differ from those in previous experiments in having the communicating-tube made smooth and lacquered to prevent premature explosion. Ten rounds were fired, at from 3° 33′ to 4° 0′ elevation; nine with 40 lb. gun-charges, and one with 60 lbs. All the shells but one, burst properly, after from 4·3 to 5·8 seconds' flight, with fuzes bored at $\frac{9}{10}$ inch and 1 inch.

In December, trial was made of double common shells for 7-pounder rifled muzzle-loading guns for mountain service. The shells provided were shorter than those provisionally adopted and used by the batteries in the late campaign in Abyssinia; length, 11·3 inches, windage, 0·06 inch, mean weight, empty, 11 lbs.; bursting charge, 1 lb., total weight loaded, 12 lbs.

Thirty rounds were provided; 15 shells of the ordinary character, and 15 others having three equal and equi-distant grooves along the sides between the studs, each groove 1 inch wide and $\frac{1}{10}$ inch deep, these groves being designed for the purpose of ascertaining whether the escape of fire through them would facilitate the lighting of the fuzes, some difficulty having been experienced with the longer shells now in the service. The gun used in the trial was a 3-inch-bore bronze-gun, of 1 cwt. 3 qrs. 6 lbs.; length, 2 feet 8 inches; and rifled with three grooves.

The first practice was with the grooved shells, to ascertain the loss of range by the escape of gas.

The second series was with live shells to determine the degree of certainty of ignition of the fuzes. In these shorter shells, the fuzes ignited satisfactorily, and therefore the shortening of the length of the shells will be sufficient to remedy the defect felt in the present service double-mountain-shells without its being required to incur the loss of propelling-power by grooving the projectiles.

Experiments were made upon the liability of fragments of the shell to be blown back into the battery, when there was a superiority of powder in the bursting charge over the charge in the gun; the ultimate conclusion being that in no case would this happen, even when the gun-charge was only 3 ounces of powder, as against 16 ounces in the shell, and the missile was exploded at the mouth of the gun. The elevations given to the gun in these experiments were from 1° to 20°.

Trials with copper-studded projectiles were made on the 5th and 14th of December, the object being to test the range and accuracy of shells respectively studded 3-inches from centre to centre, and $5\frac{1}{2}$ inches apart, fired with gun-charges of fine-grain powder, against common large-grain powder. Further practice was subsequently made to corroborate a previous experiment with common shells, having the rear-ring of studs removed.

The shooting appears to be good in all cases, as long as the studs are placed equi-distantly from the centre of gravity of the projectile. With the rear-ring of studs removed, the shooting is improved in sand-loaded shells by the nice balance made by the driving up of the

loading material towards the rear-end of the projectile by the explosion impact; but empty shells so treated, travel irregularly.

Experiments were made in October, by Mr. Abel, the chemist of the Royal Arsenal at Woolwich, in respect to shells loaded with gun-cotton bursting charges, and with a very powerful new compound, glyoxiline; the object being to discover if it were practicable to use these sensitive substances without risk of the shells exploding in the gun. The trials were made with a 12-pounder bronze smooth-bore gun, and common spherical shells, simply plugged. Some shells (1) were loaded with $2\frac{1}{4}$ ounces of gun-cotton pellets, the interstices being filled with saw-dust; others (2) were loaded with $2\frac{1}{4}$ ounces of gun-cotton pellets, the interstices filled with half an ounce of granulated gun-cotton; and some (3) were loaded with 3 ounces of glyoxiline, the charge being fixed rigidly in the shell to prevent explosion by impact on the discharge of the gun. The practice was made with charges varying from 1 lb. to 4 lbs., the full service charge of the gun, and over water to show the effects and grazes. Of the first series, one shell burst in the gun with the 4 lbs. charge; of the second series, one also burst in the gun with the 4 lbs. charge. All the others grazed many times on the water without bursting. Of the third series, five rounds were fired with respectively 1 lb., $1\frac{1}{2}$ lbs., $2\frac{1}{2}$ lbs., $3\frac{1}{2}$ lbs., and 4 lbs. gun-charges, but none burst, although this material, prepared by Mr. Abel, for its violent powers, is very sensitive. All these shells also made many grazes on the water without exploding. Other experiments were incidentally made on this occasion to show the value of exploding gun-cotton by fulminate-fuzes.

Case-shot has also come in for its share in the progress of war materials.

In respect to the defence of flanks and caponnieres, a trial was made (15th January) of a 32-pounder 46 cwt. smooth-bore cast-iron gun, converted to a breech-loader, upon Krupp's plan, and mounted upon a non-recoil carriage and iron platform having 15 degrees of slope. The case-shot provided were of 48 lbs. weight, containing 85, 8-ounce balls. At the first trial, the sheet-tinned iron-cases were too strong to break up with the small charges (3 lbs.) used; and it seemed desirable to resort to the old plan of sewing up the bullets in canvas bags. A further trial was, however, subsequently made (26th March) with a modified sheet-iron case, when all broke up, some near and some 50 yards from the muzzle, the charge used for the gun being throughout the ten rounds fired, 3 lbs. of l. g. r. powder.

An important point having been officially raised as to the probable existence of a hiatus between the limit of destructive effect of case-shot, and the commencement of the effective range of shells fired with time-fuzes, the question was brought to an issue by firing Boxer 8-inch shells, and 32-pounder spherical diaphragm-shells with 1-inch wooden-time-fuzes. Case-shot being considered effective up to 350 yards, the range from 300 yards to 500 yards was marked out into periods of 25 yards by screens from 6 feet by 5 feet up to 9 feet square, increasing in dimensions the farther from the gun, in order to meet the cone of dispersion of the projectiles from the burst.

The result showed that the 32-pounder shells did real execution at 375 yards, and that the 8-inch shells often began to take effect at 250 yards; the fuzes being all bored alike to two-tenths of an inch, the variations in the times of explosion being seemingly due to the degree of completeness or incompleteness of the ignition of the fuzes by the overlap of the flame of the gun at the moment of discharge, and not to any marked differences in the duration of the burnings of the composition of the fuze. The general results of the practice indicated the desirability of having the fuzes graduated to half-tenths.

In December, trials were made to test case-shot for the 12-inch 600-pounder m. l. rifled gun. The mean weight of the iron case, 90 lbs.; of the 255, 8-ounce iron sand-cast balls, 127 lbs. 8 ozs.; coal-dust packing, 12 lbs. 8 ozs, total, 230 lbs; Mean length, 11·35 inches. These case-shots were fired with gun-charges of 50 lbs. r. l. g. powder at rows of targets 63 feet wide and 9 feet high, representing a column of infantry; the first row being placed at 500 yards from the gun; the second row covering the first at 550 yards.

Four rounds at 30′ and two at 1° elevation of single case-shot were first fired, each one breaking up well, and some of the balls grazing at about 150 yards from the muzzle, the stream of bullets passing on with fearful violence, and cutting up the targets very much.

The extreme range of the cone of dispersion must have been nearly a mile; the lateral spread of the balls also considerably overlapped the targets.

Two other rounds were fired double-shotted; in both, the double-case broke up well, the balls first grazing at about 150 yards; the longitudinal range and lateral spread being as before.

None but those who have seen it, can realize the terrific hail-storm of metal from case-shot from 12-inch guns and 50 lbs. charges.

III. Field-Artillery.

The trials of field-guns have been mainly with respect to a subject of the highest interest—the Indian equipment.

This Indian question may be thus briefly put. For years, the Indian Government and Officers of Artillery in that great dependency have opposed the introduction of breech-loading guns, partly on account of the expense which the change from smooth-bores would entail, and partly from the difficulty experienced, with the few Armstrongs sent out, in keeping them in order. For the first seven years of their employment, even at home, the breech-screws and breech-pieces were, as is well known, constantly going wrong, patterns of the latter being changed half a dozen times in as many years; whilst the fuzes and ammunition have given trouble from the first, and are now in a worse state than ever. As India, however, could no longer with safety continue dependent on a smooth-bore system, the introduction of rifled-field-artillery was prominently brought forward about two years ago, and about the same time Colonel Maxwell, the Superintendent of the Royal Gun-Factory at Cossipoor, submitted to the government in India a proposal to re-cast the existing bronze-guns

into rifled muzzle-loaders, and he accordingly obtained leave to come home to carry out his plans. In the meantime, the general question of muzzle-loaders *versus* breech-loaders had been fiercely discussed in this country. A Committee of thirteen General Officers sat and unanimously recommended muzzle-loading field-guns for future manufacture. The Navy too positively objected to having any other than muzzle-loaders for ships and boats, and sixty-three 12-pounder and 9-pounder muzzle-loaders were actually made in the Royal Gun Factories for the Imperial service. Nevertheless, nothing was ostensibly decided, whilst great pressure was put upon the India-Office by the War-Office and Horse Guards to get the acceptance of breech-loading guns. Indeed, it had almost been decided upon yielding, when Lord Mayo stepped in, and it was reluctantly conceded that India should have muzzle-loading guns. A Committee has since been appointed to decide on the equipment, metal, and other points of detail. There is no doubt that India would benefit largely by being independent of England in the manufacture of guns, if it could be so arranged. An official board assembled a year and a half ago to inquire into the possibility of the Royal Gun-Factories supplying India with guns in time of war, and it was decided that no reliance ought to be placed on such a source. Bronze exists already in the Service in large quantities as a material, and it is one which can be produced in India itself by native workmen. Iron, especially, under those conditions of highest skill required in modern rifled-guns, would necessitate the introduction of European workmen and costly plants of machinery. Whereas, if the bronze be found, after a course of 1,500 or even 1,000 rounds, to be fit for field service, such guns will do admirably for the requirements of India, whilst the simplicity of construction and their reproduction to any extent by native artificers at a trifling cost, will compensate largely for any want of durability as compared with wrought iron and steel guns. Mr. Whitworth's system of compressing metal may probably materially add to the support of these views, by the increased durability of the bronze.

The Indian question of field-artillery is not likely to be limited to its own confines, but it is almost certain to extend its dimensions into a general imperial consideration.

The first practical trials of new field-guns took place at the beginning of last year, when practice was made to test the range, accuracy, and other qualities of three new muzzle-loading rifled field-guns of 3 inches bore—a class likely to supersede the present service Armstrong breech-loaders. It is not probable, however, that so great a change will be brought about without a considerable amount of dispute between the rival parties of artillerists; but, happily, in this paper I am able to confine myself to the Indian aspect of the question, which has many incidental reasons in its favour, and a practical trial there, it must be admitted, would be beneficial, previous to any further adoption into the general service.

We must not, however, on the other hand, forget that a good breech-loading system has many advantages for European warfare not to be over-looked, nor ought we to ignore the fact that there is a higher rate of

accident to the lives and limbs of artillerymen inherent in muzzle-loading, a risk that is increased in the use of rifled weapons.

We have alluded to the recommendation of the Artillery Commission, instituted by the Commander-in-Chief, in the latter part of 1866, and have to add here that the three guns now submitted have since been made at the Woolwich Gun Factories, to carry out this decision. The trial of them took place in January last year (1868). The weights were very uniform, being $8\frac{1}{4}$ cwts. each; all the bores were also of the same diameter, namely, three inches; but the riflings were different, No. 1 having three grooves and a spiral of one turn in 25 calibres; No. 2, with three grooves, and a spiral of one turn in 30 calibres; and No. 3, with but two grooves and a spiral of one turn in 25 calibres; all the grooves were rounded and of the same dimensions, 0·4-inch wide and 0.1-inch deep. The guns were laid at crosses at 500 yards' distance, the cross and the axis of the gun being at exactly the same height above the plane of the range. Elevation of guns three degrees. The shooting was divided into two series. First series with charges of $\frac{1}{4}$th the weight of the projectile. Second series with charges of $\frac{1}{3}$th or 1lb. 8 ozs. The two-grooved gun seemingly exhibited a slight superiority.

In March, a first trial was commenced to test the range and accuracy of a bronze rifled muzzle-loading field-gun, prepared in accordance with the proposal of Colonel Maxwell; the external dimensions and rifling of this gun being similar to those of the 3-inch rifled m. l. wrought-iron field guns previously referred to.

In May, practical experiments were made against field gun-carriages of steel, of iron boiler-plate, and against cast-iron and gun-metal naves, in comparison with wooden ones, for the wheels. Two steel $\frac{5}{16}$th inch-plates shaped into brackets, were fired at by a 9-pounder Horse Brigade field-gun with common shells weighted to 9lbs.; the charge used being equivalent to a range of 800 yards. In two hits, the steel brackets were put *hors de combat*, the steel being much indented and contorted, but the splinters not numerous. It is right to note that the brackets were not stiffened by angle-iron, as they would have been in a perfect carriage.

The like practice was continued against the wrought-iron carriage, edged up with angle-iron in the usual manner. The brackets were pierced and severely wrenched by four shots, the last breaking the left bracket in two, and the first having cut the wheel and knocked out four spokes, nevertheless the carriage still remained in a state possible to be used.

The practice against the naves showed the advantages in favour of gun-metal. The wooden nave was utterly smashed, eight of the spokes knocked out, and the rim and tyre of the wheel broken. The gun-metal nave was indented by the blow, but was forced round manually, and by taking off the washer, it turned freely over the axle-pin. One round against each nave was the test.

On the 26th October, trials of the range and accuracy of a 3-inch muzzle-loading field-gun, which had been re-rifled, were made. The shells used in the practice were weighted up to 12lbs. After thirty

rounds, the practice was stopped, on account of its not coming up to the standard expected.

IV. Iron and other Defences.

The year 1868 will be memorable in the annals of Shoeburyness, as well as in the military history of the country, for the battles of the iron defences; and although at a heavy expenditure, the practical value of the various principles involved in the discussion has been assessed, that expenditure will have been indeed well made, if the results elicited are properly accepted and carefully acted upon. In view of the strong iron-forts which Russia is procuring at all costs; the fine guns making in Prussia by Krupp; the very decided power of American ordnance, too arrogantly underrated, although not equal to our rifled weapons; and the certainty that all first-rate empires will greatly increase in the course of a period of years in the natural progress of development of military and naval manufacturing science and skill, their warlike means of offensive attack, it is clear that England must not permit the execution of inferior defences at vital points. The perfect protection of our dockyards and arsenals is of too extreme moment to this commercial country to be left unassured, and assured that perfect security only can be, by the best and most practical execution of the best and most practical principles.

Briefly, the views I personally hold are these, that iron must be employed for the most important positions such as are constantly open to close-attack in time of war, and the guns of which must be able to continue to fire without cessation, even when actually under hostile bombardment. Iron forts, shields, or turrets, therefore, employed in coast-defences must be absolutely invulnerable to the enemy's guns. Regarding the progress of improvement in the future, first-class iron defences now erecting should be capable of resisting 1,000-pounder guns, with 200 lb. charges of powder, at sufficiently close ranges, such as depth of water would allow of ships approaching within. Next I hold that it is quite sufficient to require any structure to bring up the shot, whatever its size, within the penetration of its whole length; that to bring it up more suddenly, overstrains the structure, and tends to its rapid disintegration and destruction. Thirdly, I hold that the defence is not a good and sufficient defence, if it does not keep the hostile shot from piercing, straining, or otherwise damaging the inner skin of the iron front. Lastly, I hold that the full power of resistance to the enemy's projectiles should be got out of the materials employed by the best mechanical construction and workmanship. I need not say that I do not propose invulnerable forts for every position, but only for those, the loss of which, would be national calamities. Having said so much in reference to my own views, it will be seen beforehand that I am more disposed to expect *absolute* security in iron defences, rather than comparative security.

The "Gibraltar" shield was to have had an attack made upon it on the 17th January of last year, but the 10-inch gun on its trial against a wooden screen, for ascertaining the true elevation required for precision

with a 54 lb. charge and a 400-pounder-Palliser-missile, having in its recoil shifted the slide, operations with that weapon were deferred. Two rounds from the 9-inch Woolwich rifled-gun were, however, fired against it at 70 yards, doing considerable damage.

The iron structures shot at during the memorable week which commenced on the 17th June were:—

1st. A casemate, commonly spoken of as the "Plymouth Breakwater Fort;" but in reality only a very small portion of this target actually represented the actual structure of the works now in course of manufacture: a large part of the remainder was covered with an extra 5-inch plate, and the greatest proportion of the firing took place against 20 inches of iron, the thickness of the Breakwater Fort itself being but 15 inches, and its structure a face-plate of 5 inches, backed by two rows, one horizontal, one vertical, of iron planks, 16½ inches wide and 5 inches thick.

2nd. The "War Office Casemate," a purely experimental structure with face-plates of 8, 4½, 6, and 4 inches in thickness, and intended chiefly to test backings of various forms of iron-stringers, combined with different infilling materials.

3rd. Fifteen-inch-thick solid plates, one rolled by Brown of Sheffield, one hammered by the Thames Iron Works.

Another structure, the "Millwall Shield," was inserted in the programme, but was not shot at until some weeks later; and two other structures were also down, but had no trial during the past year.

The Plymouth-target was pierced by the 600-pounder gun on its 15-inch portion; and its projectiles broke out to the rear both rows of iron planks in the 20-inch portion. Of the many rounds fired against it, two 600-pounder shot struck on the 20 inch part, one terribly cracking the face-plate, and doing considerable damage at the rear, a piece of horizontal iron bar, 14 inches by 16½ inches, equal to 2 cwt., being broken out and hurled thirty yards away; also a piece of the vertical iron-plating, 4½ by 5½ inches, was broken away, and the remaining portions of the bar fractured by more than six cracks from 6 to 12 inches long.

Two Palliser-shells used against the 15-inch part went clean through, the first piercing the target between the vertical supports; the perforation in the face-plate was perfectly round, but both the middle and rear iron-planks were broken, and turned outwards, to the distance of 2 or 3 feet. A large piece of one of the iron-planks was completely broken away. The head of the shell struck against the pier behind the target.

This round is the only one that hit upon a 15-inch portion properly representing the Plymouth structure; in all the others, the 15-inch target structure was modified, and very considerably strengthened, by the use of plates instead of planks of iron.

Another Palliser-shell struck the target under the port-hole, where are three 5-inch plates, this being the strongest portion of the 15-inch structure. Nevertheless, a piece of the rear plate, 5 feet long by about 18 inches wide, was broken out and hurled with immense force against the thick rope mantlet placed behind the target to catch the

splinters. We see here then, as distinctly as on the "Gibraltar shield," that the vibration under the heavy blows of artillery missiles, of thick iron plates against each other, is highly inimical to the endurance of the defensive structure; and that just as upon a railway, a rigid road is soon deteriorated by the blows of the engine, so in military defences, the iron plates require a suitable, slightly yielding, backing of a material different from metal, and yet sufficiently firm and so mechanically constructed as to support the plates, and take up, by the proper bearing of its different parts, the residual energy of the blow, and to distribute over as large an area as possible, the strain so suddenly brought upon a very limited area.

For this latter reason, I do not think that any practical conclusion should be drawn from the two trials made during this memorable week upon the two 15-inch plates, because they were neither of them backed in any way, and because they were set against the edges of two narrow bars, one at, or rather near, each end, a condition of affairs likely in the highest degree to facilitate their fracture. Both were broken.

Vertical fire was kept up for some days against the Plymouth target with 13-inch mortars, throwing 207 lb. shells, aimed by vertical fire against the roof, but after 200 rounds the practice was discontinued, the surface of the roof, 22 feet by 21¾ feet in superficial area, not having been struck. The range was 900 yards.

But the great feature of these experiments was the salvo fired against the Plymouth target, and aimed upon the actual 15-inch portion. The guns laid were the 12-inch, 10-inch, and 9-inch Woolwich rifled-guns, and the American 450 pounder smooth-bore. The guns were discharged by electricity, but the 10-inch rifled gun did not go off. The weight of the salvo, therefore, was 600, 400, 250—total, 1,250 lbs.—at 200 yards range. The shots took effect between the first and second vertical struts, and a large hole, big enough for a man to walk through, was cut away, giving an entrance into the casemate.

The "War Office casemate," I pass with a very summary notice, not because it does not deserve fuller consideration, but mainly because the two chief qualities it exhibited, were shown in prominence in the "Millwall shield;" those peculiarities were the soft, squashable nature of the iron used in the plates, and the hollow stringer backing.

The "Millwall shield" was designed to give several experiments, and is, therefore, neither homogeneous in structure, nor properly sightly in appearance; the main object was, however, to test a particular kind of backing patented by Mr. John Hughes, of the Millwall Iron Works. This backing consists of hollow stringers 7 inches deep, infilled with wood, and riveted up to two ¾ inch-skin plates. At the back of these is another layer of similar stringers, at greater intervals apart, the whole being supported by struts of the usual kind. In addition to this, it was strengthened by girders 12 inches deep, running horizontally, three above and three below the port-hole, and two similar girders on each side vertically, all the flanges of these girders being connected together by 1¾ inch plates. The spaces between the stringers and girders were infilled with teak, the advantage being a semi-elastic backing, highly capable of properly supporting the armour,

and distributing over the whole structure, the residual force of the impact of the shot. Another advantage of this class of construction is, that it allows the use of a much cheaper form of iron, namely, a species of rails, producible for about £18 per ton, and which, when riveted up against the skin of the shield in the form of box-girders, is a most effective disposition of the material, being weight for weight as strong, or stronger, than the material in a solid form.

I am very well aware that stress has been laid upon the interference of deep structures with small ports; but I do not see serious practical difficulties on this score.

The determination of the practical defensive value of a defensive structure is by actual artillery fire, and this the "Millwall shield" has endured to the ultimate, without giving in. After receiving shot for shot in position for position with the Gibraltar shield, it has since had several more shot-holes added to its wounds from the heaviest guns. It still remains a protection for gun and men. The details of the attacks upon it are well worth noting. The first ten of the following fifteen rounds are comparable with the attack upon the Gibraltar shield, namely: four 250-pounder Palliser shot with reduced gun-charge of 37 lbs. to equal 400 yards range; one Rodman 450-pounder shot, with 50 lbs. gun-charge; two Palliser 250-pounder shell, with 43 lbs. gun-charge; two Palliser shell, with 37 lbs. gun-charge; one 10-inch 400-pounder Palliser shell, with 54 lbs. gun-charge. After these, the "Millwall shield" was attacked with three 460-pounder shells of the same nature, with 60 lbs. gun-charge; and one Rodman 450-pounder shot with 83½ lbs. gun-charge, in all cases l. g. r. powder. Subsequently four other rounds were fired against it, the last shot, a 600-pounder, hitting it fair on the 9-inch part, and knocking the whole structure bodily back a distance of 6 feet, in spite of the strong fastenings by which it was secured in position. Its front is 12 feet broad by 8 feet high.

The invention of which I have now to speak is one calculated to produce a veritable revolution in fortifications—the Moncrief gun-carriage. One cannot well think too highly of the genius which has produced a perfectly successful means of easily raising heavy guns above the parapet for firing, and sending them back below it again into a position of safety for reloading; in fact, making the barbette system, so long the irrepressible temptation and vexation of artillerists and engineers, a realized success, instead of alternately a delusive hope and a hopeful delusion. A system of combination-fire by the guns from different batteries and pits, similar to the concentration of observations upon an approaching object for the explosion of torpedoes, is being worked out.

V. Chemical and Various.

Rockets, glyoxiline, and signal lights are all that are included in this category, and, although not strictly within the scope of a lecture on artillery practice, yet as they complete the entire series of experiments

at Shoeburyness, the few sentences required for their notice will be well accorded.

Hales 9-pounder rockets, made at the arsenal, upon a modified plan, were tested in February. Formerly the cases were made of drawn-tubing, which was liable to split. The cases of those under notice were of sheet-iron, riveted and brazed, and having three corrugations to prevent the composition giving way during flight. The tracks made in firing were very creditably straight and low. A V-shaped trough was tried as well as the ordinary tube for directing the discharge, the trough presenting decided advantages, and permitting the use of the ordinary service friction-tube. The trials showed that 10 degrees of elevation are as much as are practically useful—the composition having ceased to burn just before the rocket came to earth, with the range thus obtained.

In March, some 24-pounder Hale's rockets were fired to test a trough designed at Shoeburyness. These were placed at various distances in the trough, at an elevation of 9 degrees, and some grazed at 150, others at 400 and 600 yards distance. It was ascertained that the rockets made one whole turn in 5½ feet, as shown on the trough by the gas marks from the vent.

A V-shaped rocket-trough, made at the Woolwich arsenal, was tried in May (24th), with 12-pounder and 24-pounder Hale's rockets, at 10 degrees elevation, and answered well. The trough, 5·8 inches wide, was formed of angle-iron, and supported at the rear by two short legs, and in front by a single tall rod, with an elevating scale and clamp. The weight of the apparatus was 64¾ lbs., its length 5 feet 6 inches.

Between Southend Pier and the shore, Service-signal-lights (5th March) were tried a distance of 1¼ mile, against similar signals prepared by Mr. Abel, with magnesium in the composition, the latter having a marked advantage.

I cannot conclude this lecture without duly acknowledging the permission so constantly accorded to my applications to attend these most valuable experiments, by the Secretary of State for War, and the authorities of the War Office, and through which I have been enabled so usefully to record these important results. Nor ought I to omit to testify my high appreciation of the able manner in which those experimental-trials have been conducted by the late Ordnance Select Committee and the present Director-General of Ordnance. The courteous facilities for taking accurate observations afforded me by the Commandant and Executive at Shoeburyness, have also my grateful acknowledgement.

Evening Meeting.

Monday, April 3rd, 1869.

GENERAL SIR WILLIAM J. CODRINGTON, G.C.B., in the Chair.

NAMES of MEMBERS who joined the Institution between the 19th April and 3rd May, 1869.

LIFE.

Croft, Richard B., Lieut. R.N. 9*l.*
George, T. Barry, Ens. 13th P.A.L.I. 9*l.*

ANNUAL.

Farrant, H. A. M., Captain 1st Devon Militia. 1*l.*
Walker, J. B., Captain R.A. 1*l.*
Ogg, G. W. S., M.D., Surgeon Madras Med. Serv. 1*l.*
Hume, Francis A., Captain R.N. 1*l.*
Coffin, Sir Isaac C., K.C.S.I. Major-Gen. H. M. Indian Army. 1*l.*

MOVEABLE STEEL MANTLET FOR THE PROTECTION OF ARTILLERY AND TROOPS.

BY CHARLES B. EDDY, Esq., M.A., &c., &c.

THE defence of our country, and the protection of its defenders, are matters of such general and absorbing interest, that I will offer no apology for having availed myself of the opportunity so obligingly afforded me of bringing before you an invention intended to promote these national objects. I have, in common with many others, been struck by the extraordinary superiority which has been attained for some time past, and more particularly since the introduction of arms of precision and breech-loaders, by a mere mechanical aptitude in the use of such weapons over the great soldierly qualities of boldness and strength and disciplined valour, which formerly decided the fate of empires, and for which British troops have always been distinguished. I cannot but regard with dismay the worse than uselessness of these noble endowments when merely leading to the exposure of brave men to the sweeping and desolating havoc produced by the rifle and shell-practice of modern warfare.

My attention to the subject has been more particularly roused of late,

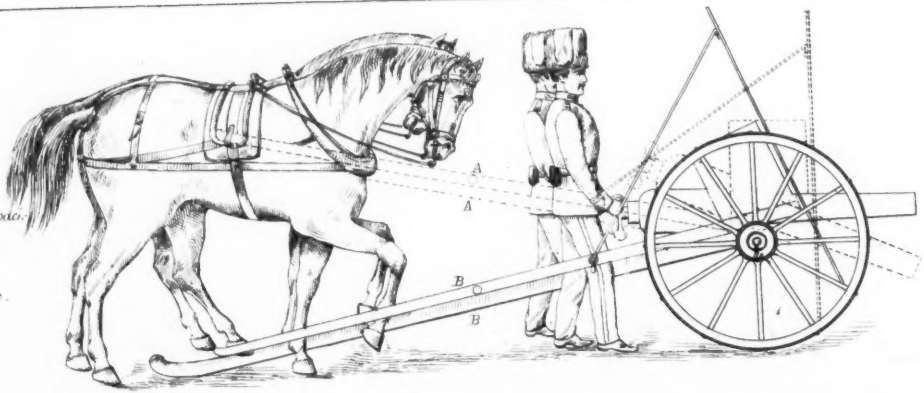


Fig. 1
A.A. Trail and Shafts when approaching enemy and under fire
B.B. d° when prepared to fire.

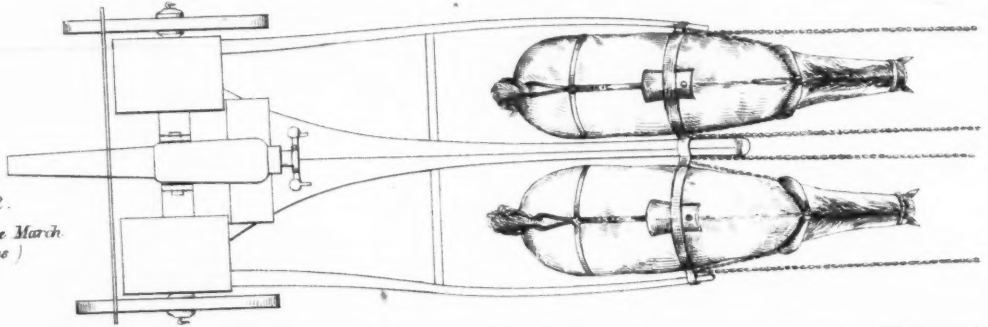


Fig. 2.
Gun on the March (4, Horses)

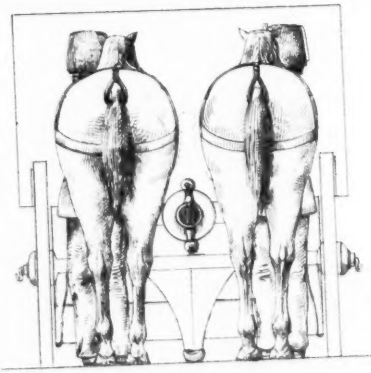


Fig. 3.
Rear View of Fig. 1.

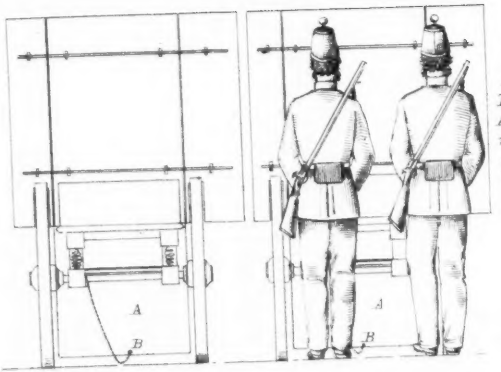


Fig. 5.
Rear View Two Mantlets.
A.A. Iron flap raised when necessary by chain B.B.

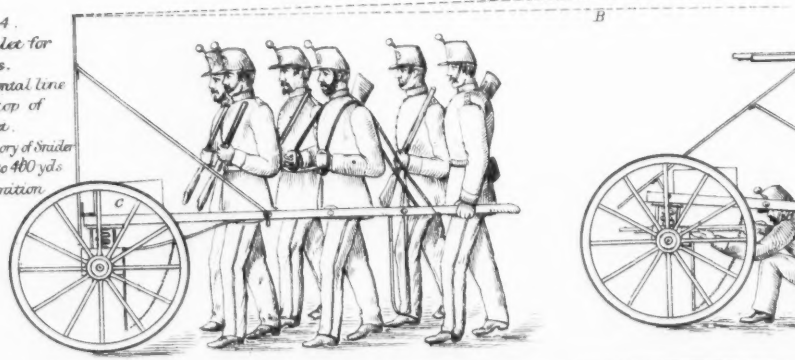


Fig. 4.
Mantlet for Troops.
A. Horizontal line from top of Mantlet.
B. Trajectory of Snider at 300 to 400 yds.
C. Ammunition box.

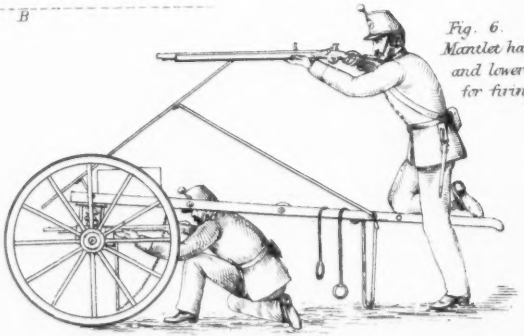


Fig. 6.
Mantlet halted and lowered for firing.

J. Jobbins

Pl. XIV.

by the deplorable and humiliating accounts which for a long period mail after mail continued to bring from New Zealand, of the discomfiture of the colonial levies by a handful of savages, occasioned solely, as I believe by the fact, that those savages, besides being skilful in the use of weapons purchased from us, habitually practice, and have become expert in methods of rapidly protecting themselves from fire; and that the British colonists did not condescend to imitate this common-sense-method of fighting, a method which they in like manner with our own troops, are apt to stigmatize as sneaking.

The disasters sustained in that colonial contest, must I think convince every one of the absolute necessity for cultivating all the methods and appliances of cover which can be made available, and indeed, it is, as I understand, a subject to which our military authorities are now paying particular attention.

The interesting work lately published by Sir F. Head, "The Royal Engineer" dwells with great emphasis on the backwardness of British troops in this respect—he says at page 352:—

"There are two facts, which I humbly submit, it is impossible for "any competent military authority to deny—

"1st. That of the armies of Europe, that of England, is at this "moment by a long interval, the most ignorant in the art of self-"defence against the desolating fire of the breech-loading rifle.

"2nd. That in its present state of wilful ignorance, it is incom-"petent to contend against any one of those highly-educated armies "above referred to, in equal numbers."

To these observations, I may add, that it is notorious, that the great contest of modern times, the American Civil War, was waged as much by the pick and mattock, as by arms. It was very soon recognized in that struggle, that some method of cover had become an essential condition of fighting; but the difficulty of inducing our troops to practise the art in time of peace, so as to acquire skill and aptitude in thus entrenching themselves, is admitted to be extreme, as witness Sir John Burgoyne's testimony.

It has been in the hope of finding a remedy for this condition of affairs, a substitute for the spade, and a method applicable alike to the defence and the attack, and also one to which men can be systematically trained, that I have devised this mantlet on wheels; the object which I aim at, being to enable our troops once more to close with their enemy, being certain that they will then vindicate their old renown, whereas, should they as now drilled, meet any of the more specially trained armies, above spoken of, one could only anticipate for them a fate similar to that of the Danes or Austrians when contending with the Prussians, or of our own Cavalry in the Balaklava charge, they would die like brave men, but they would die.

This mantlet is a moveable shield, which, with modifications for the particular purpose, may, as I think, be made available for protecting the smaller classes of field-pieces and howitzers, such as the 9-pounder breech-loader represented in Figs. 1 and 2 (Plate xiv), enabling them to advance in line with the Infantry, and with their muzzles towards the front, or for the mitrailleuse guns, such as the Gatlin, which are being adopted

in some foreign services, and may probably be introduced into our own, and which also possess the great advantage of advancing, muzzle foremost.*

I propose that these field-pieces or mitrailleuse guns should ordinarily be drawn by four horses, but with double shafts for the wheelers, so constructed as to form the trail when the gun is to be fired, and of such width, as to admit of the position of the wheelers being reversed in them, as shown in Fig. 1, that when in presence of the enemy, and preparing for action, the wheelers should thus wheel the gun, and shield before them, and the leaders draw by hooks from the naves, and that when about to fire, the shafts forming the trail should be lowered, and the gun be laid by a wedge resting upon them, the horses being withdrawn to the rear. My calculation in proposing this arrangement, is that the weight of the shield being added to that of the gun, will check the force of the recoil, and obviate the necessity for great weight and sŏlidity in the trail, which I propose to make of wood strengthened with iron.†

The mantlet may also be adapted for bringing up the ammunition, intrenching tools and stores to the front in action, and for protecting rocket-batteries. But it is also a principal part of my design that these shields shall be used for the shelter of Infantry either in approaching breaches or intrenchments, or for protecting the heads of columns formed for carrying important posts, or even for giving or receiving the attack in the open battle-field; and when drawn up, or advancing in line for this purpose, I imagine they would be useful for masking, and partially protecting the heavier field guns, whilst taking up position, and Cavalry and bodies of Infantry whilst manuœvring in the rear; for an iron wall 6 feet high would not only stop many missiles, but by intercepting the view, would make it difficult for the enemy to get the proper range of objects behind it, the height of the shields being 8 or 9 inches above the line of sight, so as effectually to prevent that. On the other hand, in order to facilitate the fire of one's own troops, the shield is adapted to be readily lowered, as may be seen in the diagram, Fig. 6. The lines of trajectory shown in Fig. 4, indicate the distance to the rear, which at near ranges, is fairly protected by a shield of the height shown, a height which, if considered desirable, might be somewhat increased within reasonable limits of weight; it must, moreover, be borne in mind, that all improvements in fire-arms, aim at obtaining a

* This engine of destruction, so formidable at near ranges, though now passing under a foreign name, was, I understand, originally invented by an English Officer, Colonel Martin, and a model of his invention has been deposited in the Museum of this Institution ever since 1861.—C. E.

† The advantage of bringing guns into action muzzle-foremost, and protected by a shield, has long been recognized. In the very earliest days of artillery, viz., in the 14th century, a plan of this kind was proposed with a mantlet, like a Venetian blind, for protection from arrows. An amusing drawing of this may be seen in the paper by Major W. H. Ross, R.A., on Field Artillery, read before this Society (see Journal, vol. xii.), but the necessity for its protection against musketry, has only risen into great importance since the vast improvements that have been made in rifle practice.—C. W.

lower and flatter trajectory, thus increasing the area of protection behind such an iron wall as this.

I look on this power of protecting artillery as one of the principal uses to which such a system may be applied, for I believe it is acknowledged to be, under existing circumstances, almost, if not altogether, out of the question to bring artillery drawn by horses, within a telling distance of a line of infantry in skirmishing order, unless the nature of the ground should happen to favour its advance; and in that case the heavier pieces, *i.e.*, the guns of the horse artillery, being unconnected with the shields, could advance rapidly, just as at present, to take advantage of it.

The infantry mantlet, which I have had made and exhibit, is of $\frac{3}{8}$ths Bessemer steel, weighing 15 lbs. per square foot; the whole plate, which is calculated to cover six men disposed as shown in the diagram, Fig. 4, weighing about $2\frac{1}{2}$ cwt. The entire machine weighs about $4\frac{1}{2}$ cwt.

The piece of the plate on the table has been proved, both with the Snider-rifle and Boxer-cartridge, and with the Martini-Henry rifle and cartridge with hardened 1 oz. ball, a weapon and missile which, without doubt, greatly exceeds in penetrating power any arm at present in use in any Service. You may observe that three shots have struck it almost on the same spot without any sensible effect; these were with the new cartridge and hardened bullet, and were fired by Mr. Lancaster at 30 yards. The resistance of this and the other plates on the table has been such as to make it almost appear that I have erred on the side of excessive thickness, but I have designed the shield as a protection, not only against small arms and canister, but against shrapnel and the mitraille from the Gatlin or other mitrailleuse guns, the balls from any of which I believe it will divert into a comparatively harmless direction, when lowered to such an angle as will still afford adequate protection to men crouching and firing from behind it. This is shown on diagram, Fig. 6. It is also intended to give protection against the explosive bullets, which are said to have so demoralising an influence on troops, and the effects of which are described as so horrible, that the use of them has lately been made the subject of an European Congress.

Against the impact of solid shot, grape, or vertical fire, this shield would, of course, be useless, and it must take its chance against the danger of a cannon ball's hitting it, or of a shell bursting directly overhead: but when the small distances at which grape can be employed with precision, is considered, it appears pretty certain that the guns throwing it would be silenced before they could be very dangerous to troops advancing under cover of these mantlets. There is, indeed, one small-arm-missile which would pierce this, or probably any shield that could be constructed within the necessary limits of weight, I mean Mr. Whitworth's steel-bolt, but the difficulties in the way of its adoption are such as probably will always preclude its general use. It will be observed that my shield is of twice the thickness of the steel sap roller invented by Serjeant-Major Knight. The thickness of this, viz., $\frac{3}{16}$ths of an inch, is, however, practically increased

to ¼ of an inch by the angle at which it is placed. A revolving musket-proof mantlet for embrasures has been proposed by Quartermaster J. Jones, R.E., and he appears to have come to the conclusion that a plate of homogenous iron, weighing only 6lb to the foot, or $\frac{1}{7}$th inch thick, would suffice. The thinnest plate which I should think safe without a backing, would weigh 10lbs. per foot, or be ¼ inch thick. The round plate on the table, however, of $\frac{1}{8}$th inch homogeneous iron, weighing 8lbs. to the foot, has resisted actual penetration, and perhaps this, with a thick pad behind it, might suffice, but the best thickness to adopt must be a matter for experiment: all that I am contending for, is the adoption of the principle. The success of this plate has suggested to an ingenious friend of mine the idea, that shields containing about 2½ square feet each, and weighing 20 lbs., might be fitted into a strong iron frame placed on wheels, so that when independent action is required each man might advance with his separate shield, as shown in the model before you. I fear, however, that unless the frame were very strong, and therefore heavy, the first shower of shrapnel would knock it all to pieces. Should the system which I advocate be taken up, and the attention of manufacturers be directed to the production of bullet-proof steel in the same manner that it has been so successfully to shot-proof armour-plates, it is not improbable that improvements may yet be made in the combination of resisting power with lightness, and that a safe mantlet for general purposes may be constructed, involving much less weight than my present shield; meanwhile however, I do not think this involves anything prohibitive in respect to weight or unwieldiness; it is run with ease by one man on hard ground, and the six men who would be sheltered by it, can all bear a hand in wheeling it whenever the nature of the ground requires additional force. It will be observed that the side pieces can be readily detached; they are intended, whilst ordinarily increasing the area of protection, to be laid across any gap or ditch requiring to be crossed, and when detached, the machine will pass through any gap in a hedge a yard wide, or an ordinary doorway.

The weight of the whole machine, as now constructed, is rather more than double that of the hand-ambulance or "China barrow," and this is intended to be wheeled anywhere by one man; but I am inclined to think, as I have already hinted, that the result of experiments with shrapnel would be to show, that the weight might be reduced without sacrificing efficiency,* and I should be glad to submit it to any experiments; it is not, however, easy for a private person to make such experiments without the assistance of Government.

Having traversed almost all those parts of Europe over which great and decisive battles have been fought, and which, as surrounding

* The quarter-inch-steel-plates on the table, which have been tested both with the Snider and Martini-Henry rifle and cartridge, prove that good plates of this thickness are practically rifle-proof, and if, as I believe, these may safely be substituted for the present ones, the weight of the mantlet may be reduced by 100 lbs., which would admit of one thousand rounds of ammunition being carried within the same limit of weight; each shield would then be a perfect volcano of fire.—C. E.

the great capitals or commanding the principal roads of approach to them, are likely to be the chief scenes of future conflicts, I feel confident that such mantlets might be moved in line across any of them when the ground is not very heavy nor the land covered by standing crops. The great battle fields of Europe, such as those of Belgium and the Palatinate, the fields of Leipzig, Jena, Austerlitz, Dresden, Ulm, Wagram, Aspern, and the plains of France, are all an open country, without fences or ditches of any consequence; in wet weather the shields might have to keep to the roads, but I think I may claim that they could go wherever field artillery could advance, and also that if the shelter they afford should enable an attacking force to advance along the roads, they would insure its penetrating or outflanking, and so carrying any position which would be worth defending; for it may be assumed that defensive positions are, and indeed must be, chosen for the defence of roads and railway junctions, or other lines of communication, and accordingly the key of a position usually rests on a road.

With reference to the adaptability of the system to the rapid movements of Armies in a campaign, it will be observed that these shields can be drawn by the men reversing their position, and this would be the easiest way on a march, and that they admit of the men's packs, great coats, arms, and ammunition being placed on them. They could also be assisted in rapid marches by horses with the lasso-equipment, with which a considerable proportion of every troop of cavalry and artillery is now provided. When it is considered that every soldier on the march must carry articles with him, the weight of which amounts to about 50 lbs., and how much more easily burthens are wheeled than carried where roads exist, I think it may probably be found in practice that, far from encumbering an Army, these machines on wheels, by relieving the men of weight, would enable them to outmarch and outflank those that have to carry their kit, that is, to do more than the present average of about ten miles a day. Supposing, however, it should be found more fatiguing for the soldiers, though working by relays, to wheel these shields laden, than to march under their kit, as now, I doubt if anything would be lost, for it is not improbable that the training requisite to enable troops to handle them freely, would prove so advantageous as to give them a clear superiority in the contest, in like manner as the laborious training which the Roman legionaries underwent to enable them to march under their ponderous arms and accoutrements, gave them an irresistible superiority when they met the foe.

The weights carried, and the marches made, by modern troops appear, indeed, contemptible, when compared with those of soldiers in the middle ages, and of the Greek hoplites and the Roman legionaries. It seems probable that the latter under the Scipios carried 60lbs. weight besides their arms and seven intrenching stakes, and their usual march was 20 miles (or double the length of a modern day's march), and we know how they vanquished their lighter armed enemies. It seems, indeed, established by the concurrent testimony of history that the lighter armed and accoutred forces have almost

invariably succumbed in the shock of battle before those which have been more heavily armed, and I think the superiority on the side of the latter may fairly, and with great probability, be ascribed to the high physical development and powers of endurance engendered by their training. At all events, weight appears to tell in the conflict. Referring to the intrenching stakes carried by the Roman troops, it is known that the legions never encamped for the night without intrenching themselves. This practice ensured them a period for rest and sleep, less subject to disturbance than can be enjoyed by troops not so protected, therefore requiring a smaller proportion of the men to be on guard and picket duty. May not this, in great measure, account for their apparently greater powers of endurance? and might not similar advantages be enjoyed by a division of a modern army, furnished with the ready means of surrounding themselves with a rampart which these shields would furnish? The proportion of mantlets, which I propose to allot to each regiment, would enclose six-sevenths of an acre, and those of four regiments combined, about ten acres, or 57,000 square yards; it is evident, therefore, that with the help of these and the artillery and ambulances, rocket, and store waggons, &c., a division might readily surround itself with a formidable rampart.

As regards the number and disposition of such shields on a field of battle, I would suggest that an army adopting them might be advantageously divided into heavy and light troops; a battalion of the former, 1,000 strong, with three or four guns in line, having say 180 shields, would show a front of about 720 ft., whilst an equal number of light troops without shields would act as tirailleurs on the flanks, and form a reserve ready to strengthen the column for the final rush. If the system of mounted infantry, which was found so useful in the American contest, should be adopted into our service, I should think a couple of horses might advantageously accompany each shield, one of which could then wheel it forward when under fire, in the manner represented in Fig. 1. The shafts can easily be adapted for this.

The lines of trajectory marked in Fig. 4 show how slight the drop of the bullet is at moderate ranges, till the nearer to the shields the more complete is the protection; therefore, it may be supposed that the instinct of self-preservation would keep the reserves well up to the front, and would deter from straggling, and thus inspire that tendency to massing and mutual reliance which is said to be so valuable in infantry, and to give so decided a superiority to the troops that possess it. Should such a method, as I have here indicated, be found even moderately successful, I think there can be no doubt but that it will confer so great a superiority on the troops that adopt it, as to force its adoption on other nations as has been the case with armour-plated ships, with the Minié rifle, and with the breech-loader, but I am far from thinking that our national advantages would thereby be neutralized. I believe on the contrary that those great qualities of British troops, calm and intrepid courage, steadiness, and endurance, which have met with such enthusiatic admiration from hostile Commanders like Napoleon, Marmont, Marshal Bugeaud, and Can-

robert, would then once more assert their proper ascendancy. I think it will be found that the adoption of defensive armour, such as this, will by no means render these qualities obsolete or useless, but rather that by wresting from the mere marksman the advantage which he now too exclusively enjoys, and by bringing the issue of battle once more to a hand-to-hand contest, it will restore the superiority to those physical and moral endowments which constitute true manhood, and to which the superiority properly belongs. I hope it may prove so, for I hold with the Chevalier Bayard, "C'est une honte q'un homme de cœur soit exposé à périr par une misérable frequenélle," and with the Marshal de Montluc, "Would to God, that accursed instrument (the arquebus) "had never been invented, many brave and gallant men would not "then have been killed by cowards, who would not dare to look in the "face him whom they murder with their wretched bullets." In fact, should some such means of neutralizing the murderous fusillade be adopted, I think a small, well disciplined body of strong, resolute, and steady men, such as our army is mainly composed of, would drive before it a larger number of inferior troops, though similarly protected, as certainly as the Macedonian phalanx, or the Roman legion drove before it the hosts of Asia and of Africa, as certainly as they themselves have borne down all opponents in the bayonet charge, a charge which is now regarded as a thing of the past, but which I hope may thus be restored. I believe our troops would thus recover that clear superiority over all continental forces which for centuries they have undoubtedly possessed, but of which the mechanical improvements of late years introduced into the appliances of war, have probably, in some measure, deprived them.

Armour has been introduced into the Navy, and it is now admitted to be an essential condition of naval engagements, why should it not be also admitted into the Army? Let it not be supposed that its use is any indication of cowardice; far from that, the shield is the very emblem of chivalry, it was the inseparable companion of the soldier during the most heroic periods of modern, *i.e.*, mediæval as well as of ancient history. Not only was it borne by the knights and men-at-arms in the middle ages, but the English archers—that glorious infantry, which so nobly sustained the honour and greatness of England during two centuries—fought behind a wooden pavois, or shield. One of these pavois may now be seen in the Meyrick Collection of Armour.

Armour was, in fact, from the earliest historic periods an attribute of advanced civilization and high culture, and continued in universal use until improvements in fire-arms rendered it impossible to carry anything that was proof against the force of gunpowder; and from that time, I think the only method of restoring the balance, and giving heroism once more a fair chance against mere manual dexterity, has been to place the armour on wheels, as is here attempted. The expense of these shields, if manufactured on a large scale, would not I think be more than 5*l.* each, in fact, as steel is becoming nearly as cheap as iron, and as one to every dozen men of a division

would probably be an ample proportion, the expense would not be extravagant. The fact, however, of the equipment of an army for the field being thus increased, in like manner with the invention of armour-plated ships, and every other improvement in the mechanical appliances of war, tells necessarily in favour of high civilization and its concomitant, wealth, for it gives an incontestable advantage to the highly-organized, thoroughly trained, and well-equipped forces of a wealthy state over the raw levies of more populous but poorer ones, to a standing army, though but small, over levies *en masse* and the Landwehr. Moreover, this advantage cannot but be enhanced in the case of a great manufacturing and commercial nation like ourselves, pre-eminent above all other nations in the possession of iron, and in the means and facilities for working it: to make an iron rampart an indispensable adjunct of armies, is to give us at once a vast superiority.

Inventions of this kind, which increase the *impedimenta* of armies, are also obviously favourable to us in our insular position, for the embarkation and the landing of such shields involve both time and the limitation for the spots for disembarkation to localities favourable for the purpose, and thus greatly diminish the chances of a surprise, the only real danger to which England is exposed.

The CHAIRMAN: If any gentleman wishes to make any remarks upon the proposal of Mr. Eddy, we shall be very glad to hear him. It is a very ingenious suggestion, but its applicability is the question. There is one point upon which I should like to ask for information: how is this mantlet to be moved on a march; and, if you are advancing to attack, how are you to move this with the men carrying their knapsacks and rifles?

Mr. EDDY: Each of these will shelter six men, and all the six men can help to move it and follow it. The way in which they are harnessed in, is simply by a rope with a handle in it, which they can drop in a moment. They carry their rifles in one hand, and with the other pull the rope. The thing is easily run over hard ground, such as a good road, by one man, because it is so evenly balanced that there is no weight on the handles. I believe six men can run it anywhere, at all events, anywhere where field artillery can go.

The CHAIRMAN: What is the height of the wheels?

Mr. EDDY: Rather more than three feet. The weight of this plate which I have made three-eighths of an inch thick, is 4½ cwt. But I have no doubt, whatever, that I can easily reduce the weight. With plates of this thickness (pointing) it would be only 3½ cwt. And if these plates (pointing), which have been proved with the Henry-Martini rifle, were considered sufficient, they would reduce it still more. The weight of this plate is only about half.

The CHAIRMAN: Is it a steel plate?

Mr. EDDY: It is of homogeneous iron, and the whole weight of this plate is about 3 cwt.; so that for six men each man would only have to wheel half a cwt. Then, instead of carrying their knapsacks, they would, no doubt, strap their knapsacks on to the box, and the box would carry their ammunition protected by the plate in front. Each of these boxes would carry 1,200 rounds of the new arm. 1,000 rounds weigh about 100 lbs. But on the march, with the plan of mounted infantry, which is very advantageous, the best way would be to attach one horse at least, say two horses, which could wheel the shield independently of the men. This drawing (Fig. 4) shows the protection which the shield gives to six men, they are almost entirely protected, except part of the leg of one man.

Colonel GRAY, R.A.: May I ask how that light field gun (Fig. 1) is propelled? how is the draught thrown on to the weight of the gun? and how is the shaft attached to the horse and then to the gun?

Mr. EDDY: By a chain and a hook.

Colonel GRAY: Do you fancy they exert the same motive power traced in that way?

Mr. EDDY: Certainly not; but they can be reversed on the march (Fig. 2). Four horses can be attached as at present. In action they would be under cover, attached in the same way as horses are attached to a Crosskill's reaping machine (Fig. 1). The resistance to a reaping machine going through a field is very great; but it is found that two horses put on behind can push a reaping-machine forward and cut the corn down. In the same way this shield can be pushed forward in front of the enemy. It is intended that two horses shall propel the machine when it is under fire, and then the horses are taken out to afford cover for the men (Fig. 3).

Colonel GRAY: Can you take that gun over a hill?

Mr. EDDY: I do not know that I can in this way (Fig. 1). But four horses could draw it, just in the same way as they do at present on the march. It is only in the presence of the enemy that two horses, protected by the shield, would push it forward. Still, they would have the same power that horses have in pushing a reaping machine.

Colonel GRAY: Do you think the shield adapted for field artillery? Suppose the shield were shot away, do you not think the gun would be rendered unserviceable on account of the want of a proper trail?

Mr. EDDY: I propose that this should be of wood, strengthened by iron. It is a long trail; therefore, the weight need not be so great.

Colonel GRAY: You say the shield exercises a certain amount of compensating weight for lightening the trail? It appears to me that your gun would be rendered much more easily unserviceable than one of our present guns. Do you not think it would?

Mr. EDDY: Very likely. But then, it seems to me a great point to protect your horses under fire. At present the horses are unprotected.

Colonel GRAY: If the shield were shot away, I should think the gun would be rendered unserviceable by one shot.

Mr. EDDY: A shot might pass through it, but I do not think the shield would be carried away. Of course, a gun can be easily disabled by a shot now.

Colonel GRAY: Of course, that is the difficulty. Yours is a very good plan if you can carry it out.

Mr. EDDY: In all these things there must be a balance of advantages and disadvantages. There can be no advantage without some corresponding disadvantage. But I suppose it would be a great thing to bring up guns under heavy fire with protection to the horses, because within moderate ranges it is so easy to disable a gun by shooting a horse; if you can protect the horse it is a great point gained.

The CHAIRMAN: That is supposing your artillery fire is less effective at any distance than infantry fire. Is that the fact?

Mr. EDDY: I should have thought it was.

The CHAIRMAN: That is the question.

Colonel GRAY: The range of the Armstrong gun is fully equal to that of any rifle that has been invented; therefore, I think you would find in an artillery engagement that your gun would be much more quickly unserviceable than the present style of gun.

The CHAIRMAN: The question is, why should you bring your guns under the fire of infantry if they have a superior fire?

Colonel GRAY: It would be a mistake to bring your artillery under infantry fire. All your men and horses would be probably rendered unserviceable.

The CHAIRMAN: You do not propose your shield as effective against any artillery fire?

Mr. EDDY: No; but against shrapnel, yes.

Colonel GRAY: I think that is its weak point, that the gun would be quickly rendered unserviceable.

Major MCGWIRE: Another objection appears to me to be that if the shield were struck by a rifled shot, the splinters from it would have the same effect on the men and horses that a shrapnel would. If that shield were struck by a shot it would fly into splinters, and they would act as a shell.

The CHAIRMAN: It is made of wrought iron, is it not?

Mr. EDDY: Yes, of wrought iron.

The CHAIRMAN: I do not think that wrought iron would have the same effect as cast iron.

Major McGWIRE: But if the shield were split.

Mr. EDDY: I have not had the opportunity of trying it with a round shot, but I fancy a round shot would go through it.

Major McGWIRE: I think you would find that it would be shot away in a very short time.

Mr. EDDY: This plate shows no splinters. It has been fired at with one of the new bullets, lead hardened with tin. I fancy as the shield is made of homogeneous iron, that a round shot would go through it.

Major McGWIRE: That drawing (Fig. 4) represents the shield on level ground. If the men were marching on very fair ground they would be able to see the ground that they are marching over. But over rough ground they could not possibly keep their order of march.

Mr. EDDY: It is only when the men want to be protected that they would not march freely. The shield is so light that one or two men can run it alone over any ordinary ground. It is only when they are in front of an enemy, and want the protection of the shield, that the men will crowd behind it. Then they would be in the order shown on that drawing.

Major McGWIRE: Another disadvantage strikes me. That seems suitable for level ground, but in attacking a height, the troops would, in nine cases out of ten, have to descend a hill into a valley before they could ascend the height upon which the enemy is posted, and they would be exposed all the time they were descending the hill and crossing the valley.

Mr. EDDY: Whenever they want to fire they can lower the shield in this way (Fig. 6). There is another way of protecting themselves, that is by kneeling with one knee on the frame; the other leg is protected by the wheel, and they fire over that. It forms a breastwork, only the head is exposed. But if they wanted to fire a distance of a thousand yards they would pull up the shield and fire lying on the ground.

Major McGWIRE: It is very hard in manœuvring troops to keep line or formation of any kind; even to form front from column is very difficult, because the men have to work zig-zag, they seldom come in a straight line to arrive at their point. Has the shield ever been tried under these circumstances?

Mr. EDDY: No, I have only just made this shield; but if the men were attached to the shield, and were protected by the shield, I should have thought that they would keep close behind it for shelter.

The CHAIRMAN: There is no doubt that all these are interesting subjects for discussion. Whether the inventions are practical or not, is the point that we are met here to consider, after one has had the opportunity of looking at them. The difficulty with all inventions of this kind, is their portability; how are you to get these things to the places where they are to give cover? There is no doubt that a gabion, a rifle-pit, or a steel mantlet, or anything that can give cover, is a very good thing, but how you are to get these things, invented to give protection, where they are wanted, appears to be the difficulty. There is no doubt that the discussion of these questions is exceedingly interesting in a military point of view. We are very much obliged to Mr. Eddy for bringing this plan before us, and for the trouble he has taken in giving rise to a discussion on an interesting point of military warfare.

AMMUNITION SUPPLY CAR.

By Lieut.-Colonel T. Martin, late 4th K. O. Regiment.

The supply of ammunition to meet the requirements of the present breech-loading rifle has necessarily become a matter for serious consideration: the fear that men will expend too many cartridges in action has already been expressed by high authorities, and all sorts of *dodges* are had recourse to to prevent soldiers firing too fast; for instance, shouting out the names of men to fire during independent firing, desiring men to expend only two or three rounds on any given occasion, or making men count twenty paces between each shot while firing as skirmishers halted. Hints to Commanding Officers, entreaties to Officers, cautions to Supernumeraries, and orders to men, fail to restrict the expenditure of blank ammunition on pageant field days; the only means I can recommend, for conquering the *propensity*, is to tie two rounds together, and thus compel the men to untie them before firing them off. All this firing may answer to keep public expectation up to the mark; because, on such occasions, a "bouquet" of fire becomes as essential at the conclusion of a field day, as at a gala-night at the Crystal Palace.

If field-days are for the gratification of an admiring public, and to be got up cheaply, let us by all means obstruct the soldier in his endeavour to shorten the field day by showing off his Snider; but when our field days are for instruction, the soldier should be taught the real value of his breech-loader, and to become acquainted with "his own power," and how to use it on occasion when the favourable turn of the tide of battle may depend upon his being able to fire rapidly and well.

It does not require much experience for a private soldier to learn the value of *ball* ammunition on service; he may on a field day do his best to get rid of *blank* ammunition, in hopes of shortening the drill, but, in action, the consciousness that his life may depend upon the good use he makes of his *ball ammunition*, will influence him not to waste it.

We must not now-a-days judge of the soldier-element by the antiquated standard, which counted it perfection "that soldiers should not think;" that old-fashioned brutalizing idea has been swept away, and the educated British soldier of 1868 "thinks," and feels, that he has as much right to indulge in the luxury of thought as any one; and it cannot be denied that the march of intellect in the British soldier has kept pace with the improvement in his weapons.

"Extra ammunition" is now the outcry, and many suggestions have already been made, and experiments tried, as to the number of rounds a man should carry, and how he ought to carry them, but *all* agree upon flooring knapsacks during actual service.

As the map of Germany was changed in seven days, we may modestly suppose that any other map may be altered in a fortnight. We all

know that a man can be clothed and shod to meet the wear and tear of fourteen days' Moose shooting in Canada, without requiring any change but socks; why then should we not profit by this knowledge, and learn to dress and equip our troops for a fourteen days' war? We should leave our knapsacks or bundles in charge of the Control Department during war, at any point we start from for fourteen days' real active work. Give us plenty of ammunition, some dried beef, biscuit, and preserved potatoes, not as rations, but merely to carry in the event of rations failing on any particular day, or on getting too far a-head to receive any. We might ease the soldier of half the weight of his present knapsack, and still give him extra ammunition, a light waterproof, a blanket, a pair of extra socks, reserve food, a piece of soap and a towel, taking care to distribute these *valuables* conveniently and judiciously on his person. I have not mentioned boots, because they could always be supplemented from the enemy or the killed.

I now come to the stumbling block of all advance parties, out-posts, skirmishers, and indeed of lines and squares—the supply of Ammunition. There is no part of our regimental system so incomplete; I therefore hope that my endeavour to meet the deficiency may prove acceptable.

I have here a small ammunition hand car, of my construction, which can supply 40 rounds per man to a subdivision (Plate xv, fig. 1). This car can be drawn with perfect ease by a pioneer, drummer, or bandsman, and does not occupy more than a man's standing ground in the ranks, in column, or in square. The revolutions of the wheels are registered on a dial, which indicates the distance marched by the subdivision, a considerable advantage, because places to advance or retreat upon, can be accurately measured and marked for the information of others; the cars, however, need not all be provided with registers.

If it be feared that some men will fire rapidly in action merely to get rid of the weight of their ammunition, here then is a remedy, because when a man knows that there is a reserve supply of ammunition at hand, to make good his "wilful waste," he will scarcely take the trouble to fire quicker than absolutely necessary. One of the great advantages of this mode of supply is, that men will feel more confidence when they know that they are *backed* by a reserve of ammunition, and have not to trust to being supplied by means of draught-animals led by cowardly muleteers.

The pioneers of the period when fully equipped are neither useful nor warlike; they seem strapped, buckled, and pinioned to pickaxes, crowbars, and knapsacks. I would relieve the pioneer of his burden, and carry more useful tools on the "hand-car," or give each man a small pickaxe or hoe on service, as the French have. The car should carry a few gun-spikes, some tourniquets, plaster, and bandages for the use of the sub-division.

These ammunition hand-cars would also serve as magazines to out-posts, picquets, trenches, &c.

During action the ammunition of the killed and wounded could be collected in them for future supply; after action they would serve to remove the dead and wounded.

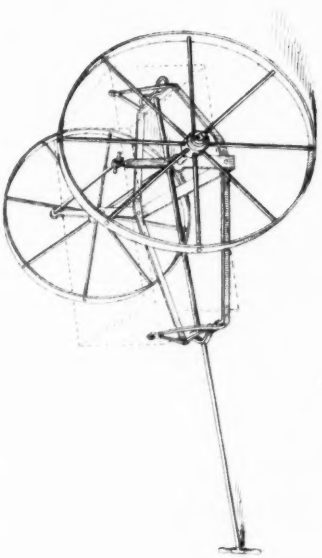


Fig 2

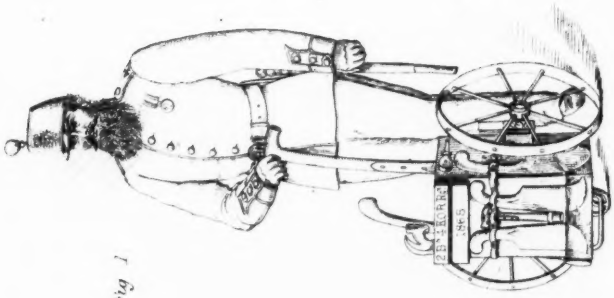


Fig 1

In time of peace they could be used for the removal of ball ammunition to and from magazines, or for the issue or collection of blank ammunition. They would prove of great service in judging-distance-practice, reconnoitring, route marching, laying out lines for trenches, and bases for surveys.

Instead of ammunition, some of these cars might be used to carry intrenching tools, and one or two ought to be fitted with surgical implements and a few useful medicines, which might be the means of saving many valuable lives.

This ammunition-supply-car is of full size, has wrought iron wheels and axle, and is consequently not liable to injury from bullets. The handle by which it is drawn, is a pioneer's spade, the blade of which and the two bill-hooks protect the ammunition.

SKELETON AMMUNITION CAR.

I have also constructed a skeleton-car (Fig. 2), on which the ordinary regulation rifle-ammunition-case or box can be placed, the box forming the body of the car. A box of ammunition can thus be conveyed to any part of the field, and when delivered, the skeleton car be returned to the magazine for another box.

The ammunition should be packed, according to my method (see Plate xvi, fig. 1), in cases containing 720 or 880 rounds; one uniform size and shape should be decided upon, and the *cars* made to fit them. The lid of the box should be made to slide out, to save the trouble of breaking it open.

In an admirable paper read at our last meeting, on the subject of "Military Transport,"* everything desirable seemed to be provided for, except a safer means of supplying ammunition *during action* from the divisional and brigade stores, to the troops actually under fire.

We must still depend upon railways, waggons, &c., and sumpter animals for the conveyance of rifle ammunition *from* the base of operations *to the* field of action, but, arrived *there*, it must be halted, magazines formed at a safe distance from the enemy, and the supply beyond *that point* must be continued, as I have already said, by means of hand-cars.

A bundle of 10 rounds of rifle-ammunition weighs 1 pound 5 drachms, therefore a case containing 720 would weigh 73 lbs. 6 ozs., and 880 rounds 89 lbs. 11 ozs.

Supposing one case to contain 880 rounds,

The weight of the cartridges would be	89	lbs.	11 ozs.
The box	5	„	
The car	40	„	
Total	134	„	11 „

About half the weight of the China ambulance barrow when *empty*.

* See Journal, vol. xiii., page 263.

This barrow was adopted for the conveyance of wounded men. Its weight is 234 lbs., and allowing 154 lbs. (11 st.) for the weight of the wounded man, we have a total of 388 lbs.

If it was *really* intended that one man should push or pull this barrow, no complaints are likely to be made about the weight of my diminutive cars, and when we recollect that our old veterans used to carry 75 lbs. weight, without including rations, it is not difficult to believe that a man can pull or push *double that weight* on wheels.

If this skeleton-car be adopted for ammunition, I think the other car I previously described might be used, with *immense* advantage, to carry pioneers' tools, intrenching tools, medicines, and surgical appliances, which every man ought to be taught to use. I tried the experiment in the regiment I commanded, and every man in it knew how to dress and bandage wounds, set fractures, stop hemorrhage, and improvise stretchers, tourniquets, &c., &c.

AMMUNITION FOR THE SNIDER RIFLE.

It must be merely for the convenience of packing and to economise space that the "Boxer Ammunition" is done up in packages of *ten* cartridges placed alternately *Cap* to *Bullet* (see Plate xvi, fig. 2), an arrangement by which five percussion caps on each side of a package are liable to explode if hit, and the danger of explosion is terribly increased by the hard points of the bullets being placed, as they now are in kegs or boxes, in contact with the caps of the next package.

I have shown by several interesting tests, the damage which a small bullet, fired from a pistol into a box of rifle ammunition will produce, and proved beyond question, that the present mode of packing cartridges is the worst, and most dangerous that could be adopted.

The metal cylinders containing the powder are a great protection against spontaneous explosion, but a bullet fired into a pouch would cut through several cartridges, and all the loose powder would naturally blow up with sufficient force to burst the cylinders of the other rounds in the packages, cut into. I therefore beg to recommend:—

1st. That all cartridges as now packed, should be placed with the *exposed ends* of the packages towards the *top* and *bottom* of the pouch (Fig. 3), an arrangement which would considerably reduce the chances of explosion, because an accident could only happen from a shot being fired from a height into the top of the pouch, or by a piece of shell striking it from below.

2nd. As to the old pattern pouches, in which one of the compartments is too narrow to receive two packages with the cartridges *upright*, they should never carry more than three packages, *two* in the larger compartment, and *one* placed diagonally across the smaller.

The new pattern 50 round-pouch (Fig. 4), issued in 1866 to some Corps, has 5 compartments, too narrow to receive "Boxer's Ammunition"

Col[l] Martin's System
of packing Ammunition in a Case containing 850 Rounds

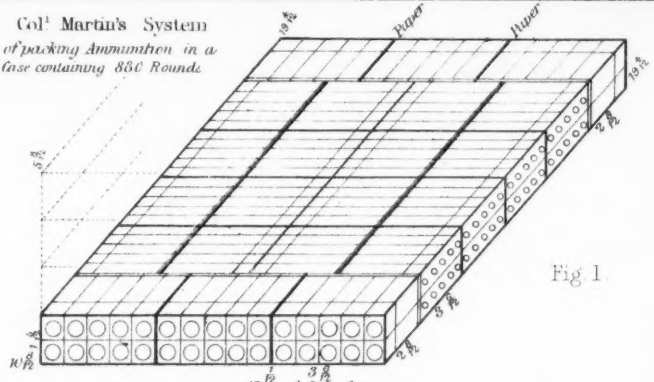
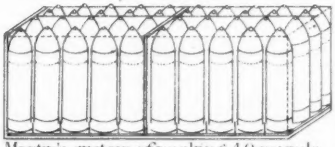


Fig. 1

Fig. 5.

Col[l] Martin's Plan of squaring the base of Cartridge



Top of Pouch

Fig. 3.

Rearview

Col[l] Martin's system of packing 40 rounds in a new pattern Gov[t] Pouch

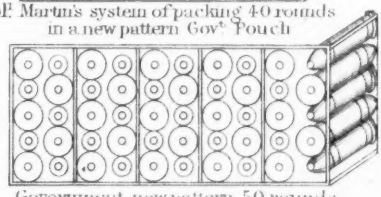


Fig. 4

Government new pattern 50 rounds Pouch rear view 2½ 25 perc[d] Caps expo[d]

Government System
of packing Ammunition in a Case.

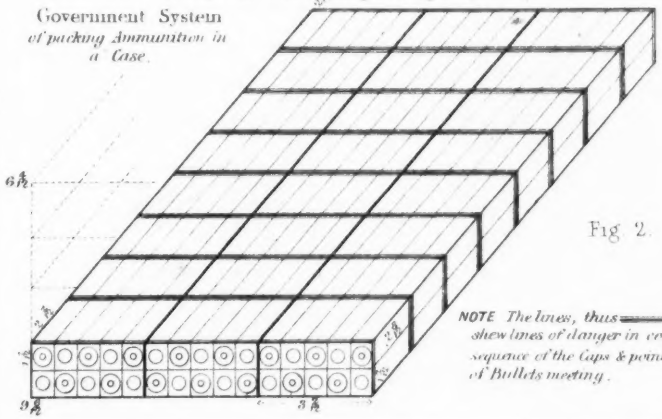


Fig. 2.

NOTE *The lines, thus* ═══ *shew lines of danger in consequence of the Caps & points of Bullets meeting.*

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placed cartridges *upright;* consequently the ammunition can only be stowed in the compartments *sideways*, that is with 25 percussion caps facing the *rear*, and subject to be struck whenever the soldier retires while skirmishing, or is faced about when manœuvring.

In order to remedy this most serious objection, instead of these 5 compartments for 50 rounds, the tins of these pouches should be altered to two longitudinal compartments for 40 rounds; and any extra ammunition that may be considered advisable for a soldier to carry in war-time should be arranged in "ball bags," according to a plan which has yet to be decided upon.

This only affects pouches; but kegs or boxes of rifle-ammunition would of course be as awfully liable to explode as they now are, because the caps *front* on two sides, at least, over the whole extent of the interior surfaces of any box or case they may be packed in, and this exclusive of the risk from a diagonal fire.

This danger admitted, I now propose packing the cartridges, with the caps or bases towards each other, and the bullets *outwards*, done up in packages of 10, 15, or 20 to suit new compartments in pouches (Figs. 1 and 3); for the simple reason, that as the caps are sunk in the metal where the "anvil" is, they would afford mutual protection, and the bullets being outwards, the caps could not be reached; moreover, if a bullet were fired sideways into a package, the cartridges would not be liable to explode as they now are. To make the bundles square for the convenience of packing, I also propose squaring off the projecting rims of the base disc of the cartridge which does not in the least prevent the certain action of the extractor at the breech block (Fig 5).

If the new Martini-rifle-cartridge which is longer, and weighs 9 grains more than the Snider is to be dealt with, the same method of packing can be applied, even if it be advisable to put 15 in one bundle, but the discs should be partially squared, and the new rifle extractor adapted to the arrangement.

With a view to rendering my small "Ammunition Supply Car," safe from explosion, I have at the gain of a little space, packed the ammunition according to my plan, and I am ready to *test* it with kegs or boxes packed according to the present system.

The great drawback in all campaigns has been the difficulty attendant upon supplying ammunition to detached parties while engaged, and I may not be far wrong in stating that this inconvenience has been felt from the early part of the 16th century up to 1868.

We are informed that during the late Prussian War, the want of ammunition for breech-loaders was not at all felt; this is not surprising, when we consider that the Prussians had it all their own way; but, if their enemy had also been armed with breech-loaders, the presumption is, that there would have been outcries for ammunition on both sides, and it is not improbable that some of the engagements would have been concluded with the bayonet.

We may safely infer from what we know of breech-loaders, that in the next European War, the Army best supplied with ammunition.

and the means for intrenching at its most advanced posts, will have the best chance of success.

It is very remarkable how little we have improved since the Peninsular War, in the supply of ammunition by day to troops under fire. Then, as now, mules or horses were laden with two or three kegs of ammunition tied on pack-saddles; a muleteer was sent to the front in charge of two animals, and soldiers were frequently told off to aim at him until his load was deposited; arrived at the first batch of troops he let the kegs fall and made off. The kegs were then broken open with the butts of muskets, the ammunition required was appropriated, and the remainder left on the field; and we have often been told by old warriors that kegs upon kegs of ammunition were deserted for want of transport when an advance was ordered, and that they had frequently to hold their ground without a cartridge in their pouches.

The heroes of Inkerman, armed with the old fashioned muzzle-loader, after expending their ammunition, had to fight with the butts of their muskets, stones, and the toes of their boots; and at the Redan it was impracticable to convey ammunition to the active front on account of the broken ground.

Here then are instances which come nearer to us, and which might occur again to-morrow, when carts and horses and sumpter animals would more certainly fail us, not from lack of men "stalwart and true" always ready to drive them, but because armed as all European troops *now* are, we should be merely driving our cattle to certain destruction.

The lesson we have to learn from all wars up to the present time, not even excepting that in Abyssinia, is, that we must not depend solely upon draught or sumpter animals, but render our troops independent, by providing for them a convenient means of conveying with them at *all times*, and under *all circumstances*, a *reserve of ammunition*.

I have been asked, how my "Supply-car" would act in ploughed land? I reply, that it will be found to act better than any other known means of supply, and will cost considerably less. Mules or horses laden with ammunition sink into the soil, they frequently break down and the men who lead them, have to load and re-load them, and have often to lighten the burden by casting away a keg or two of ammunition; again, the animals and the men have not only to be fed, but both become grievous impediments, the moment their load is delivered, or lost, and if our present system be persevered in, and our ammunition packed as it now is, we shall find our military-transport carts, men, horses, and sumpter mules blown up, or shot down, simply because they would become a mark for the enemy.

The disadvantage of supplying ammunition to troops *under action* by means of horses or mules is manifest from the fact, that the man or the mule, or both, may become wounded or shot and the ammunition lost, or sufficient explosion might take place to cause the animal to cast his load and become unmanageable.

My "Supply-car" is so small, that it is not likely to attract the enemy's attention; its wheels are sufficiently broad to enable it to be drawn easily over ploughed land. The pioneer, in light marching

order, in charge of the "Supply-car," assisted by a drummer or bandsman, would keep pace with the men of the sub-division; for it must be borne in mind that the men have to march heavily laden over the same ground; moreover, the car being so small and handy can be lifted on to narrow pathways, or over ditches and obstacles, and being perfectly water-tight, can be drawn through rivers or streams by means of the rope attached to it. Supposing the pioneer and the drummer or bandsman to be shot or wounded, the rest of the sub-division would take care not to desert their car, and many hands would make light work; on level ground a drummer could draw it for miles. Women propel far heavier burdens all day long on our pavements and highways; and young girls may be seen during the potatoe crop wheeling greater weights in common wheelbarrows through ploughed fields. What these can do in their daily avocations ought not to be considered too much for soldiers on emergency.

It would be interesting if we could ascertain how much of our national debt is attributable to losses in mules and horses, and unexpended ammunition supplied during action. If our loss was considerable in days of flint locks and short ranges, what will it be now, under the same supply-system, with a rifle ranging with deadly precision to above 1,000 yards, and capable of unloading seven mules in a minute? If we can bring ourselves to sufficient perfection to make our seven shots tell, we may be sure our European enemy, if we ever have one again, will be able to compete with us in long ranges at substantial marks.

The transport of ammunition on mules, &c., or in waggons by day, should now cease when within a safe distance from the enemy's fire, and depôts should be formed whence to replenish men's pouches and re-fill the "supply cars" of regiments. The regulation barrel of ammunition contains 760 rounds; a mule with two such barrels would therefore carry 1520 rounds. My "Supply car" contains 880 rounds, consequently one car to each subdivision would give 17,600 rounds per regiment, carried free of all expense, except the trifling cost of the cars, there being 10 pioneers, 20 bandsmen, 10 drummers, and 10 fifers, really non-effective in action, to take charge of them, not including the men who might be enlisted instead of muleteers.

The advantage in the way of economy alone, of my system must become acknowledged when the following facts are taken into consideration:—

1st. The immense expense attendant upon the purchase, transport, feeding, shoeing, and extra commissariat carriage for forage, say for 17 mules per regiment, 12 being required to carry conveniently 17,600 rounds in barrels on heavy pack saddles, and 5 in reserve.

2nd. The paying, rationing, &c., &c., of the veterinary surgeons, and at least 16 men for conducting and keeping the mules, besides farriers, forges, tools, &c., for shoeing and for repairing pack saddles.

3rd. When troops are moved by rail on any sudden emergency in war time, sumpter animals and their conductors, forage, pack-saddles, barrels of ammunition, &c., have all to be stowed in different parts of the train, thus causing endless confusion and delay. Arrived at its

destination, the train has to be unloaded, mules dragged out, pack-saddles and ammunition searched for and fastened on, whereas my diminutive cars can be run in and out of railway carriages without being unpacked, and on the line of march they can be lifted over walls or any other obstacles impracticable to mules.

All we have ever read in history fails to afford us an idea of what our future battles will be; common sense, and common sense only, must guide us, taking our data from the knowledge we have of our weapons, and the good use our soldiers can make of them. We must be careful that every possible provision be made to imbue the soldier with confidence; and the best way to effect this is, to let him know that he has an extra supply of cartridges at hand, and has not to trust entirely to being relieved by supports before he can honourably quit his post. It was with a view to this that I improvised my "Supply-car," and in making it also carry the means of preserving life, spiking guns, and the tools necessary for removing obstacles, cutting wood, and entrenching, I have added not a little to the safety of the men; and as in retreating, it will mark fairly the distance from an object, we shall be able to adjust our rifles all the more accurately when we make a "stand;" last, not least, if the car be fired into, the cartridges packed according to my system, will not explode.

Our future fights will never again exceed the best portion of a day, and more than sufficient for that day will be the evil thereof, if we go not forth lightly equipped and our pouches and canteens heavily laden. We are prone to depend so much on "pluck" that we are often improvident in our arrangements, but if we should ever require to display our national gift to its greatest advantage in the field, the soldier must become his own mule, muleteer, doctor, cook, and engineer.

MILITARY INVENTIONS.

How is it that we, who as a nation are considered so supremely *practical*, seldom seize upon a military idea or a military invention *of our own*, until it has been returned to us Frenchified, Prussianized, or introduced to us as *the very* last Yankee notion?

The fact is, military inventions are not encouraged. Inventors have many difficulties to overcome, and are not much assisted by those who have it in their power to protect them.

1stly. By increasing the practical utility of this "unique" Institution, and *making it at once* what it is struggling hard to *make itself*, and 2dly, by protecting *bonâ fide* British *military* inventions and improvements, and affording facilities for *fairly testing them* without favour or affection, *not* cavilling at *expressions*, but entering fully into the real merits of the invention, persons would be saved the expense of *patenting* inventions that can only be taken up by Government. I can venture to speak with some degree of *experience* on these matters, because I have suffered losses from piracy on several occasions when my duties called me from one *end* of the world to the *other*, and I

became practically acquainted with the *fact* that the *equilibrium* of our charming planet is not *in the least* disturbed by *any preponderance* of honesty at *either end.*

Among other things my "war-truck" now called by the Americans the Requa Battery and *réchauffée* by the French into the "*mitrailleur*," was made by me at Aden in 1860, when I saw in the Journal of this Institution that it was proposed to fortify London, but that the enterprise was likely to fail because there would be difficulty in procuring sufficient men to furnish three reliefs to the enormous works in the event of an invasion. I provisionally patented the "war-truck," and presented it to Government in January, 1861, as I was about to start for India again. My duty called me to Canada seven years after, and on making a tour in the United States, I saw my "war-truck" ready for use at West Point Academy, New York, and another at Niagara Bridge, imitated in everything but its diverging fire, which my American friends did not perceive was one of its main features; and I *can*, I am sorry to say, instance other similar transactions which have compelled me to have recourse to the expense of completing my patents.

Select Committees are so very liable to "*disestablishment*," and have so little time to wade through the proceedings of their predecessors in office, that many useful things are lost sight of. May we not therefore hope that this Institution will yet become the official custodian of our war appliances, and consequently of our individual interests in relation to military inventions?

Colonel MARTIN then exhibited and described his "war truck," and "rifle battery," invented in 1860.

The CHAIRMAN: How many rounds will your supply car carry?

Colonel MARTIN: This is made for 1,000 rounds. But I should prefer 880 rounds, packed in 88 bundles, because we can pack 880 rounds in it so that they will not explode. The authorities at Woolwich have tried, and they could not explode my packages in pouches. The 88 bundles weigh 89 lbs.; therefore, there are 89 lbs. in the cart besides the tools. Two or three of these carts *without ammunition* would suffice to carry all the extra pioneer and entrenching tools of a regiment.

The CHAIRMAN: Is this for one pioneer?

Colonel MARTIN: For one pioneer; but up or down hill a drummer-boy would assist him.

The CHAIRMAN: What is the diameter of the wheels?

Colonel MARTIN: These are 2 feet 4 inches; but I would make them two or three inches higher, because the cars would then be easier to draw. In the "skeleton car" the centre of gravity is below the wheels. If the other car is considered too heavy with these tools on it, I would adapt it for nothing else but entrenching tools, and make them carry tools up to 2 cwt.

The CHAIRMAN: The tools for the pioneers?

Colonel MARTIN: For the pioneers. Then, let the drummer-boys and the bandsmen, and the men who would otherwise be employed as muleteers, have "skeleton cars."

The CHAIRMAN: The subject that has been mooted is a very interesting one, the supply of ammunition in the field particularly. I dare say there are some gentlemen who would wish to make remarks upon the feasibility of Colonel Martin's proposal.

Major McGuire, 1st Royals: I think there is an inconvenience in having the handle removable in this supply car?

Colonel Martin: That is for carrying entrenching tools, and I have made the spade serve for a handle, for the simple reason that a handle would weigh something, and it is desirable to save weight. But with these straps I can also draw the car. In going up or down hill I can also block the wheels, thus, with them; and if I want to lower the car into trenches, or into deep ditches, there is a rope attached by which I can do it. The spade or handle is easily put on by means of this clasp and hook, and the "jemmy," can be attached firmly to it in an instant. You need not take off the handle unless you like, but if you found yourself in a plain, you could make it useful as an entrenching tool. Everything on the cart I have endeavoured to make useful.

The Chairman: How many pioneers did you say?

Colonel Martin: Ten pioneers. Then, there are all the bandsmen and all the muleteers. If you do not have this car you would require a muleteer and a mule.

The Chairman: The question with regard to horses carrying ammunition is, whether a horse cannot carry a greater supply of ammunition to any place where you want it, than man's labour can.

Colonel Martin: The answer to that is, Which is most liable to be shot?

The Chairman: Quits as to that, I should say.

Colonel Martin: Because, in one case you have got the muleteer and the mule, two lives. You cannot have a mule without a muleteer.

The Chairman: But you can put 2,000 rounds of ammunition on the mule.

Colonel Martin: But you have got a man and a mule. If the man is shot the mule is of no use; and if the mule is shot, the man is of no use, and you lose your 2,000 rounds of ammunition. This is the way I argue, *the loss ensues, whichever life* is lost. Then again, you have *two* to feed instead of *one*. Whereas, in my case, if the man is shot, the car does not run away; another man can go for it and pull it back, or take it forward. There are always plenty of men in the field.

The Chairman: Do you think you can use that car in deep ground?

Colonel Martin: Yes, particularly the skeleton car, because I have made the wheels half way up the box, and the gravity is below the wheels, so that it cannot upset.

Captain Burgess: Will you show the car turned upside down?

Colonel Martin: Yes. Supposing it to tumble over going down hill, I could drag it just the same.

Captain Burgess: And you can turn it round on a pivot?

Colonel Martin: Yes. It does not require its own length to turn it in. I have a pivot here, and it turns on that pivot.

The Chairman: That car holds 1,000 rounds in one box?

Colonel Martin: It holds 880 rounds, which is all the ammunition I want to be packed. That is the safest way it can be packed; it can never explode. During the six years I commanded a regiment, I felt the want of something of this kind; but it was not until lately that I became aware that the new ammunition, as now packed, was so extremely liable to explode, and during the late Irish elections I took upon myself to alter the position of the packages in the men's pouches. I then thought how imperfect my car would be if the ammunition in it were packed according to the present system, and I hit upon the plan I now show you.

Captain Burgess: Have you practically tried it?

Colonel Martin: I have practically tried it. Every one of the Woolwich pouches blew up, but not one of mine.

The Chairman: The cartridges you exhibit were fired at from the outside?

Colonel Martin: These were fired at in pouches packed according to my plan.

Mr. Stirling Lacon: Have the Government recognized it?

Colonel Martin: Yes, they have thanked me for it. Here is the Government pouch, and here is mine. My danger is from below; but the pouch is not likely to be struck from below. It is a simple arrangement, and I think it a safe one.

The Chairman: Will you alter the outside of the pouch?

Colonel Martin: Yes; they will all have to be altered, just as they will have to be altered for the Henry-Martini cartridge.

Major MACGUIRE: You will not have to alter the rifle for the cartridge with the square base?

Colonel MARTIN: No.

The CHAIRMAN: As possibly no other remarks will be made, I may say that we are very much obliged to you, Colonel Martin, for coming here to give us this practical explanation of your inventions. Of course, there will always be differences of opinion as to whether inventions of this kind are completely applicable in the field. There is no doubt that discussions on them are of the greatest possible interest; and there is no doubt as to the ingenious and serviceable adaptation of your inventions, as you have shown us this evening.

Evening Meeting.

Wednesday, May 5th, 1869.

ADMIRAL SIR HENRY J. CODRINGTON, K.C.B., in the Chair.

SHIP-RAISING; ESPECIALLY WITH REFERENCE TO HIS EXPERIENCE IN RAISING THE RUSSIAN SHIPS SUNK IN THE HARBOUR OF SEVASTOPOL.

BY COLONEL JOHN E. GOWEN, U.S. Army.

MR. CHAIRMAN AND GENTLEMEN,

It was with no small diffidence that I accepted the invitation with which your distinguished Society honoured me to read a paper to-night on my experience in raising sunken vessels, but I feel sure you will accord me your indulgence and consideration, when I tell you that it is the first time I have lectured on this or any other subject, and you will agree with me on the wide difference between such a position and the conduct of those submarine operations to which the greater portion of my life has been devoted.

From time immemorial, the process of raising vessels in a tideway by means of the rise and fall of the tide has been considered the only certain method of effecting that end, and my system is purely a scientific application of the principle therein involved, with the exception that I am independent of the tide.

It is not my intention here, to enter very fully into the various schemes which have been brought forward, some partially successful, some totally impracticable, and others never yet tested; but for a number of years the question has been one of the greatest interest to me, and I think there are but few, if any of the tested or suggested processes which have not come under my observation, while many of them I have myself employed with varied results.

About the year 1849 an invention was submitted to the United States' Government, having for its object the raising of vessels by means of air-tight cases composed of several thicknesses of canvas and india-rubber, with a strong netting on the outside. On a trial which took place with a view of ascertaining the value of this invention, as a means of carrying a vessel over a river's bar, it is notable that a sloop of war in Baltimore having a number of cases attached, (if I

recollect 20 on either side) was only raised some 18 inches on their inflation. Government, however, purchased the apparatus, and subsequently discovered that for the intended purpose (viz., the raising of submerged vessels), the method was a complete failure. I shall further on have to refer to a case in which I also experienced the same results with it.

Other and very costly apparatus has been designed, principally one or more, for raising by powerful hydraulic pressure; but I am not aware that either of such modes has been practically tested, and those I have seen in model are open to serious objections for practical working, though in theory, they are all that may be desired.

Bishop's Floating Derrick, and its failure, is doubtless fresh in the recollection of all here, though it may not be known, that prior to its introduction into this country, it was tried in the United States; but as I before said, my intention does not lie, even if time permitted towards criticism on others' schemes, but rather to lay before this Institution some of my experience, and an explanatory statement of the method, which after a long course of disheartening failures and difficulties overcome, enabled me to achieve most perfect success.

About the year 1845, the United States steam frigate "Missouri" was burnt, and sunk in the Bay of Gibraltar, causing an obstruction, which was the subject of complaint by the British Government. On its representation, the United States' Government undertook to remove her, and in various attempts expended no less a sum than £20,000 without success, the Engineers reporting it was impossible by human ingenuity to effect the desired end, and in 1851, on a second application from the British Government, it was resolved to make a further attempt, and I was honoured with a commission to carry out the operation.

I found the vessel (a first-class war steamer) sunk in about 6 fathoms, and laid over broad on the bilge, having about 3 fathoms clear over all, and completely covered with sand. Government had forwarded 20 of the before-named air bags for me to test, which I accordingly did, and succeeded most effectually in bursting up the greater portion of them without getting an aggregate lifting capacity of 9 tons, and this happened generally before they were half inflated, though each bag was supposed to be equal to more than 5 tons. I concluded that the only effectual means of removing this vessel was by exploding gunpowder beneath her keel, and the process I adopted was as follows:—

I had constructed pointed cast-iron cylinders some 7 feet in length 14 inches in diameter, and 1½ inches in thickness, having about 3 turns of a screw cast on the point (similar to a screw-pile) filled with gunpowder, and closed by caps secured with screw-bolts. These cylinders were placed outside the vessel in such a manner, that on being driven through the sand some 30 feet, they would arrive beneath the vessel's keel. To effect this, I used a shaft of wrought-iron constructed to fit over the head of the cylinder. This shaft worked from a raft on the surface of the water, and was turned down in the same manner as the screw-pile now in use, so that by its means the cylinders were placed in the required position, and the shaft being removed, were exploded

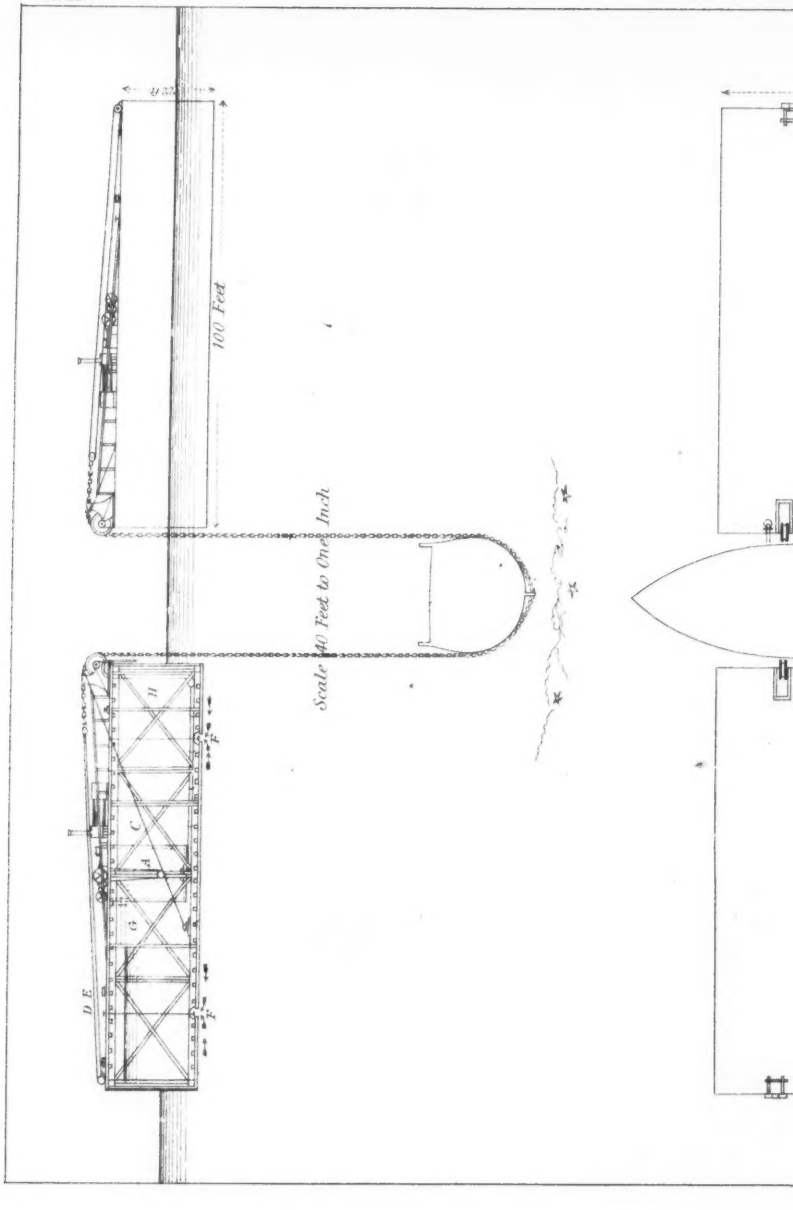
by electricity. The vessel was in this manner broken up, raised piecemeal, and I received a certificate from the British authorities that the obstruction was cleared to their entire satisfaction.

Shortly after this, in the year 1854, my attention was called to the steam-ship "Erie," burnt and sunk with great loss of life on the Lake of that name. She lay in about 10 fathoms, and several attempts had been made to raise her, amongst others, one by "Bishop's Floating Derrick," before referred to. Report alleged that the vessel contained about £75,000 in specie, and thousands of pounds had been spent in endeavouring to raise her, but up to that time without success.

It appeared to me, however, to be anything but a hopeless case, and with very little difficulty, I succeeded in raising her entire by means of chain-falls working from two open trussed frames, the ends resting on hulks on either side, and towing her into Buffalo Creek, hauled her ashore, and cleared out the contents, from which I recovered £1,000 in silver, and a mass of amalgamated metal, supposed to be gold and silver, which appeared to promise so rich a harvest, that I refused an offer of £10,000 for one-half share. Taking the metal to New York, it was submitted to assay, and I was informed six days would be necessary to make the investigation; on the day appointed, however, when I attended with some friends to learn the extent of my good fortune, to my surprise and dismay, I found that the result of the assayers' six days labour was the production of two small bars of silver, value in all about £145, and that my gold was transmuted into the less precious, though useful metals, which had composed the connections and fittings of the engine of the sunken vessel.

Did time permit, I would call your attention to various other experiences prior to my undertaking the operations in Sevastopol Harbour, but as this is more especially the subject on which I have the honour to appear before you this evening, I will now proceed with it.

In the year 1856, I received a communication from the Russian Minister at Washington, to the effect, that his Government wished to negotiate with me for raising the sunken fleet at Sevastopol, and on this invitation, I at once proceeded to Moscow, and had an audience through Prince Gortchakoff, with the Grand Duke Constantine, who requested my views upon the practicability of clearing the harbour of the numerous obstructions which the policy of the Russian Government had created. Having previously given the matter most serious reflection, and decided upon the only plan which, to my mind, bore a probability of success, I showed his Imperial Highness plans of caissons somewhat similar to those exhibited this evening, and he at once desired that I would undertake the work. Acquaintance with the difficulties surrounding such a task, increased the hesitation I felt in undertaking at all a labour of such magnitude, but ultimately on the representations of the Government, I accepted the contract, on terms subsequently materially differed from (resulting on account between us in a balance of about £50,000 in my favour, which I fear will never be liquidated); and in the spring of 1857 I arrived at the scene of those operations, which were to extend over the five succeeding years.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H
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J. Jobbins

Though, doubtless, many here have a personal knowledge of the harbour and roadstead of Sevastopol, I will, for the information of those unacquainted with them, exhibit a rough sketch showing also the positions held by the sunken vessels, which, I may here state, were found to be imbedded in an average depth of about 19 feet of mud, clay, gravel, and shells; in some instances reaching a depth of 23 feet.

Making no comment upon the many theories propounded on the subject before us, but confining myself simply to a statement of my system and its results, I will at once proceed to an explanation of the appliances I used.

In the first place, I had intended to use four caissons on a smaller scale than those shown in the diagrams, to which I shall shortly call your attention, and I may be better understood when I state that on being tested, these four caissons had an equal lifting capacity with two of those I am about to refer to. The material for their construction I brought with me from America, and they were designed to lift by chains through centre well-holes, on which principle my first attempt was made. It was obvious to me that such a process must bring the caissons together as the vessel rose, but I trusted by the use of heavy anchors to keep them apart, and was scarcely prepared for the result. As the vessel lifted I found no means which I could adopt, would prevent the caissons closing, and when so closed, no power could start them, although I had at my command powerful steam craft, gunboats, &c. These I employed without the slightest success, never, in any instance, being able to get one inch of division, even when using steam vessels of 700 united horse-power.

Here was a grave difficulty, and in addition to this, doubts arose whether I had sufficient lifting power to compass the end in view. I might raise a vessel until the broken masts and top hamper touched the caisson's bottom, but could never hope to bring her to the surface; and, in the first instance, it must be understood that I was working upon the smaller vessels.

I determined, therefore, while altering the caissons in use, to construct two others, having a lifting capacity equal to the four smaller ones, and for this purpose had to go some hundreds of miles into the country to cut the necessary timber.

Suspending all raising operations until the new caissons were completed, I took the field with the six, and if you will kindly follow me to the diagrams, I will explain in some detail their construction, taking one of the larger ones for illustration.

The outside shell of the caissons (Plate xvii) was constructed of timber, zinced on bottom and sides up to three feet, and divided into six water-tight compartments, in the centre ones of which was the well or pump chamber, marked A on the diagram. This framework was braced with trussed or open girders in such a manner as to give the whole structure the greatest strength and rigidity consistent with maintaining the necessary buoyancy and distributing the strain when engaged in lifting over the whole area of the caissons. The cast-iron wheels over which the lifting-chain passed,

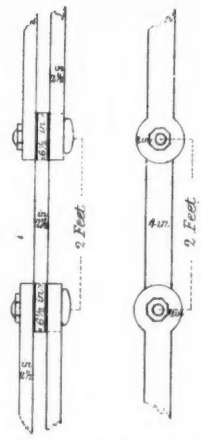
it will be seen, were also braced and supported by the iron bar C in the diagram. Each caisson was provided with a portable engine of 15-horse power to work the powerful centrifugal pump in the pump-chamber A, as also the winch above, to which the falls D, E, were taken. At the points marked F, F in the diagram are shown the valves for the admission of water, which were worked by means of spindles as shown, reaching to the deck and opened or closed by a key-wrench. Between each compartment were sluice valves admitting the water to flow equally into such of the compartments as might be necessary. The pipe G led from the pump through the side of the centre compartment for the expulsion of water, while that marked H connected the pump with the hose used, as hereafter referred to, for pumping out the vessel when raised.

In raising weights of less than 1,000 tons, I rarely needed to submerge the caissons, but admitting water into the after-compartments to act as a counterpoise, I could with ease run such burdens to the surface by means of the five-part fall, hooked on to the lifting chain, and taken to the steam winch. The majority of the vessels, however, which I raised, being of far greater weight, the process I adopted for them was as follows, by which mode I had a lifting capacity of over 5,000 tons.

Pre-supposing that the caissons were moored in proper position above the sunken vessel, and the lifting-chains passed beneath the bottom (which process I will hereafter explain), the valves at F and the sluice-valves were opened, and water freely admitted into all compartments till the caissons were submerged to within a few inches of the surface of the water. All valves were then closed, the chains hauled taut by the falls, and water being retained as before in the after-compartments, that in the fore-compartments was expelled by pumping, the vessel was correspondingly raised, taken in tow to shoal water together with the caissons, till she grounded, when the operation was repeated, until the deck came above the surface, all leakages were then roughly stopped, and the hoses leading from the pipes H passed into the vessel, and the pump set to work till she floated, and allowed me to clear out the accumulated mud, rubbish, and ballast. It will be seen that if at any time there was an uneven strain on either of the chains, the caisson would immediately cant, giving an opportunity of re-adjustment before such chain could part.

With the chains lay the great difficulty; the ordinary chain-cable of familiar form was, as I knew, from former experience, of no avail, invariably when subjected to a heavy strain drawing out and crushing the stud, and when I commenced operations it was with a chain consisting of solid iron links, each 2 feet in length, pinned together in a manner not unlike the chain which passes round the drum of a watch. This chain, as shown in Fig. 3, plate xviii, was manufactured of best American iron, 2 inches thick by 4 inches in width, and connected by a 3-inch steel pin; with it I was partially successful, but after parting it like pack-thread, more than 100 times, I concluded it would be necessary to procure some other chain capable of resisting the heaviest strain which I could expect to meet with. I accordingly designed the chain

Fig 3



Scale 2 Feet to 1 Inch.

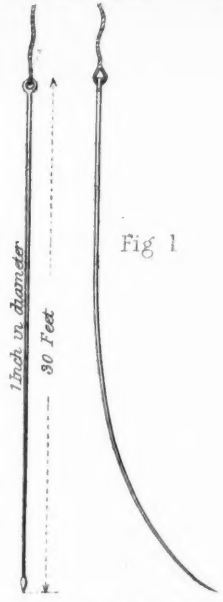
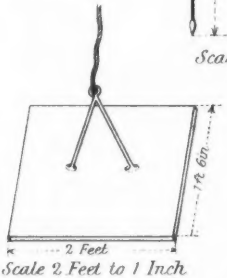


Fig 1

Scale 10 Feet to 1 Inch.

Fig 2.



Scale 2 Feet to 1 Inch.

Fig. 4.

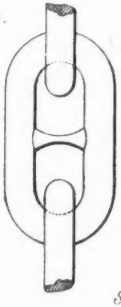
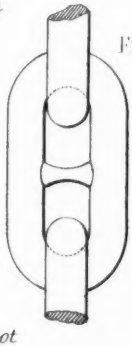


Fig. 5.



Scale 1¼ Ins to a Foot

J. Jobbins

shown in the diagram, the smaller (Fig. 4) being for use on the lesser caissons. The larger (Fig. 5) was probably the heaviest chain in use up to that time, and its links, it will be seen, are constructed with only a sixteenth of an inch play on either side, the sides being parallel. I was, of course, obliged to send to England for this to be made, and forwarded the design through my agent to Messrs. Brown, Lennox, and Co., with instructions to manufacture it of Low Moor Iron. They, however, telegraphed me that the form of chain was bad, and it ought not to be made of Low Moor Iron. Considering myself the best judge from experience on both these points, I could only reiterate my instruction, and at last received the chain as ordered. It answered completely, never parting in a single instance, and the form, I believe, is now in use to some considerable extent.

And now to refer to what doubtless is a matter of some curiosity on the part of every one, and was to me, I can assure you, the greatest difficulty encountered, namely, the slinging of the vessels.

I had secured enormous lifting-power, which, for a long time, bid fair to be useless through my inability to connect it with the weight to be raised. Every method of slinging I tried, without success, and it is only those who have had practical experience with the subject, who can form an adequate idea of the difficulty of working ponderous chains of the character used.

It has been my lot, more than once, in conversation with gentlemen interested in this question and owning inventions of more or less merit, to hear them say, "I should pass this chain *here* or *there*," as if they were speaking of a watch-chain. Why, when one considers that each link of such a chain as must be used in these operations, weighs nearly a hundred weight, the "passing" referred to, is a process that I venture to say, among theoretical projectors, has in no case received the attention it demands, but is too often taken for granted; and such gentlemen start off on their theory with the vessel slung, when that is the point at which they should commence. This suggests to me that possibly I should have explained *my* method of slinging in an earlier part of this lecture. But again I have to ask your indulgence for reasons before stated.

On every attempt to sling, either by sweeping or girdling the vessel, the chains parted, or slipped; when I led the chains through the ports, they cut up through everything; I then had recourse to the following expedient upon a 60-gun frigate.

With the difficulty necessarily attending such work, conducted at a depth of some 60 feet below the surface of the water, I succeeded in cutting four holes through on either side of the vessel below the orlop-deck, about 16 inches in diameter, and after crowning the same with one-inch boiler-plate, passed the lifting chain through the apertures, hauled taut, and attempted to weigh the vessel. The chains cut up through everything, and thus another failure was registered.

I was now convinced that the only method which would answer, was bottom-slinging, and, turning my attention in that direction, succeeded at length by the following simple method, in placing chains with the greatest success and expedition beneath every vessel on which I subsequently operated:—

Fig. 2 shows a flat iron scraper, on about ½ scale, about 2 feet in width and 18 inches in depth, composed of ¼-inch-plate iron to which a strong iron-handle is riveted.

To this handle was made fast a rope, taken to a capstan in a vessel moored alongside, and the diver, having adjusted it against the vessel's side at a point where the chains were required to be passed, it was drawn away from above through the mud, re-adjusted, and re-drawn until a channel was made following the vessel's side to within a short distance of the keel. The diver then made use of a long curved, flat-pointed iron rod (Fig. 1), having an eye in the head through which passed an inch rope. This he pushed under the vessel's keel, and it was drawn through from the other side by the diver occupying the corresponding channel.

In this manner a way was opened for the introduction of small chains, and ultimately of the heavy lifting-chains used, which were hauled through from above.

This, which threatened to prove an insurmountable obstacle, was thus overcome, and from that time I experienced no other difficulty than occasional bad weather.

It must be remembered that the whole of the operations were conducted in an exposed position with no tideway. Here, however, is shown a great feature in the system. The caissons, when in use in heavy weather, had only to be submerged where moored, and thus would ride out any gale of wind; and during the whole of the time I never experienced an accident to one of them. With equal facility they were towed even in fresh weather, corner-on in line, and it was only during the frequent heavy gales that operations were suspended.

A few remarks upon the undertaking generally may not be uninteresting. Immediately after the battle of the Alma, the first line of vessels was sunk, all-standing, between forts Constantine and Alexander. The terrific gale subsequently, when so many of your transport vessels were lost and damaged, cleared away all those parts of the masts and rigging which had previously shown above or near the surface of the water.

These vessels had been sunk with all their guns, but in only one instance was this the case in the subsequent sinkings.

The authorities, after sinking the first line of vessels, had the batteries of the remainder of the Fleet removed, replacing them with large blocks of stone of equal weight, the guns so removed, going towards the equipment of the fortifications on the land side.

On preliminary investigation of the sunken fleet, it was found that the teredo had made fearful ravages in the upper works of the wooden vessels, that timber only having escaped, which had been covered or coated with mud. The extent to which this pest of those waters had completely honeycombed every inch but what had been protected, would have appeared to me almost incredible, had I not been an eye witness of it. Specimens of timber containing the teredo were forwarded by me to the Russian Government, and I believe are now shown in the Museum at St. Petersburgh, and in other museums throughout Russia. During my stay in Sevastopol, two blocks of wood were forwarded for

me to test, one coated with a composition which it was asserted would defy even the teredos' attack; but after four months' submersion I found each equally perforated. The maker of the composition in England troubled himself to write me several letters on the subject, urging me to state to Government the result of the test; finding he would not otherwise be satisfied, I was compelled to make what could not be other than an unfavourable report of his composition.

I was especially successful in the raising of the iron vessels. In the case of the war steamer "Elbooroos," which was docked, even the paint was in order, save where the chains had chafed, and the vessel is now in commission as the yacht of Her Imperial Majesty the Empress of Russia.

While raising another iron war-steamer, the "Danube," I found it necessary to apply the lifting power rather far out towards the stern and bows, in order to avoid the paddle-boxes, but on attempting to raise her, the bow and stern made their appearance on either side, and, finding there was no possibility of raising her entire, I adopted a novel expedient, and by taking advantage of the experience gained through prior calamities, cut her up in half, and having constructed coffer-dams, puddled with clay, raised her in two pieces, which parts were floating about my works subsequently for at least three years. In all I raised and cleared over sixty vessels from the roadstead and harbour, 27 entire, the rest being so badly burnt that they broke in raising, and came up in pieces.

In conclusion, and trusting that I have made myself understood in this brief reading, I must express my surprise that no perfect system of salvage exists in this country, and that day by day, valuable vessels are lost and allowed to go to pieces often without an attempt to raise them. In New York, Boston, and other places, my process is in use, or about to be used, and it is my wish to introduce it into this country, feeling sure, that even as a commercial transaction it will pay handsomely. Turning only to the past year, and close at home, we see the "Foyle" sunk in the Thames, and given up after various attempts as a hopeless loss; the "Leichardt," run down at the Nore; the "Florence," off the Isle of Wight; together with many other vessels which were easily reclaimable, had proper appliances been at hand.

Should caissons be constructed in this country, great advantage would be gained by using iron throughout, and various other improvements have also suggested themselves to me which would perfect them. I am convinced by the experience which I have this evening endeavoured faintly to shadow to you, that no better process is extant; with it, a certainty has been achieved, and I may be pardoned for the foregoing confident assertion, when reflecting that no perfect success under equal difficulties has ever yet resulted from operations carried on for the raising of sunken vessels, while we all know the fabulous sums expended in futile attempts.

It is a startling anomaly that the greatest maritime nation of the world is absolutely destitute of any certain appliance for the salvage of sunken property.

I have laboured this evening under considerable difficulty in attempting to give you an outline of my "experience;" but if I have been enabled to afford you any interest I am amply repaid for accepting the, *to me*, novel position of a lecturer.

The CHAIRMAN: Would any gentleman like to ask Colonel Gowen any question upon this subject, so as to elucidate the matter further. I am sure the Colonel will be very glad to give us any further information that he can.

Colonel GOWEN: Very gladly. Here are different specimens of wood that have been under water a considerable time, showing the effect of the *teredo*. This first specimen, I believe, is a portion of the steering wheel of the "Twelve Apostles," and the worm has produced upon it most astonishing effects; I could hardly believe them myself. I have collected for the Russian Government, and preserved in alcohol, specimens of the *teredo*, that were one and a quarter inches in diameter. Here is a piece of wood that has been submerged 167 years. It is a portion of the gun-wheel of one of the French vessels sunk in the harbour of Vigo in 1702. The *teredo* has made considerable havoc on this. The wood is otherwise as sound as when it was first manufactured into a wheel.

Captain BURGESS: Perhaps Colonel Gowen would describe the teredo, and how it works?

Colonel GOWEN: The body seems to be composed of mucilage; the head is a species of shell, very hard indeed, pointed not unlike an ordinary auger. The length of its body, I should think, is about twenty times its diameter. The hole which it makes in entering the wood is scarcely perceptible, not much larger than the point of a cambric needle. As you see here, the inside of the perforation is as smooth as possible, much more so than could be effected by mechanical means.

The CHAIRMAN: Do the chambers run into each other?

Colonel GOWEN: The chambers are very small; they are usually separate.

The CHAIRMAN: Is the action at the end of the shell? Is it by attrition, or is it by the action of hydrochloric acid?

Colonel GOWEN: That I hardly know. It is assumed that a portion of its body, adhering to the wood as a fulcrum, constantly turns round the shelly portion, forming its head, and so bores through the wood It is necessary, in order to secure the *teredo*, to split the wood directly it comes out of the water, otherwise the body of the animal turns into water, it is such a mucilaginous substance. At Sevastopol they are extraordinarily large.

The CHAIRMAN: Do I understand that the depth of the Russian vessels in the mud was 19 feet?

Colonel GOWEN: From 19 to 23 feet.

The CHAIRMAN: They were actually submerged in the mud that depth?

Colonel GOWEN: Yes; the vessels were submerged that depth in the mud. Wherever the vessels are submerged in the mud, and wherever the sediment had settled upon any portion of a vessel, the *teredo* never entered it, and even while the paint remained, they never entered it, otherwise they perforate very quickly indeed.

Admiral Sir EDWARD BELCHER: Will you allow me to ask by what process you manage to disengage vessels when sunk to that depth in the mud, because they would create, as it were, a vacuum beneath them, and it would require a great deal of tickling and ingenuity to make them quit their beds? If you could manage to get air beneath them you would be able to make them move. I would also ask whether you have any mode of ascertaining the weight of these vessels when removed from the mud and suspended in water, so as to calculate upon the powers that you would require to lift them even a foot?

Colonel GOWEN: In the first place, nine-tenths of the vessels in the harbour of Sevastopol were in 20 feet of mud, gravel, oyster-shells, and very hard clay about the consistency of the London clay. But invariably these vessels had gone down and their keels rested upon the solid stone. The bottom of the harbour is of lime-stone formation, and the swell of the sea beating upon the vessels produced a slight

swaying motion, so that there was usually a little space on one side or other of each vessel, and for that reason they weighed a little more when under the mud than after we had extracted them.

Sir EDWARD BELCHER: I mean when you had raised them out of the mud altogether, had you any mode of determining what their weight was? I suppose they were filled with mud?

Colonel GOWEN: All filled with mud. We had a mode of detecting that by the displacement of water. I had marks inside the caissons which denoted the number of tons by the quantity of water which had been expelled from them. The "Vladimir" weighed about 5,000 tons. She was the heaviest vessel, and was entirely filled with mud.

Sir EDWARD BELCHER: Then, in point of fact, as to the lifting power, you fill the caissons and let them sink to a certain depth, and then pump out the water?

Colonel GOWEN: Yes, pump the water out. You will observe there is a compartment running longitudinally across the vessel. This compartment is constantly filled with water, and when you commence lifting, it acts as a counterpoise to the weight which comes from the opposite end. Then there are sluice valves between these compartments, so that you may regulate the quantity of water. It is like the old fashioned system of raising an anchor by the use of a long barge; they heave the head of the barge down, and then jump on the stern.

Sir FREDERICK NICOLSON: Before the meeting closes I should like to express my regret that Colonel Gowen's paper was not placed on our card in the usual manner, because I think we should have had a much larger audience. It is a subject of very great interest, and I am sure it has been brought before us in the clearest possible manner. It was owing, I believe, to the absence of Colonel Gowen that the Council of the Institution were unable to place his name on the card. To ask one question, I did not quite catch whether the diagrams of the caissons were drawn to scale?

Colonel GOWEN: They are drawn to scale.

Sir FREDERICK NICOLSON: Because when they are published in our Journal they will be very valuable if they are drawn to scale. As I understood, you had only two caissons?

Colonel GOWEN: Six.*

Sir FREDERICK NICOLSON: Six to each vessel?

Colonel GOWEN: Yes.

Sir FREDERICK NICOLSON: Did you find any difficulty in getting the same strain on the chains from the different caissons? Because, in raising a vessel by "lumps" the great difficulty is to get the same strain upon all the lumps that are used. You have alluded to the "Foyle" that was sunk in the River Thames. The "Foyle" is an instance of the want of such appliances as Colonel Gowen's for raising vessels in the Thames. She was first taken in hand by a private individual. He had two small frigates placed at his disposal by the Government; he had as many chains as he could get from Woolwich and Chatham; yet, in the end, he found it impossible to raise this vessel—a vessel certainly not so heavy as many of the vessels that Colonel Gowen has raised. When it was afterwards taken in hand by the Conservators of the Thames, they found she was completely filled with mud; and owing chiefly to the difficulty of giving an equal strain upon the only lighters that they could apply to her, they found it quite impossible to raise her; and it ended in her being blown up. But the meeting will perhaps be glad to learn that she is now so entirely removed, that there is no obstruction to the navigation. I am sure we must all feel grateful to Colonel Gowen for having placed this matter before us. We sailors know how extremely difficult it is to do work under water; and when you come to these great depths of 60 feet, or 10 fathoms, in addition to the great depth of mud, we can conceive how difficult it is to raise even a small vessel; much more such large vessels as were sunk in Sevastopol. May I ask what was the size of the chains that you used?

* In Plate xvii only four caissons are shown.

Colonel GOWEN: About three-inch, of Low Moor iron. You were referring to the vessels and to the unequal strain coming upon them. You observe the chains pass over these wheels, and that if the strain is unequal, the caissons cant on either side, and adjust themselves to the weight.

Sir FREDERICK NICOLSON: You are speaking of one caisson?

Colonel GOWEN: No, of all six.

Sir FREDERICK NICOLSON: How do you get the same strain on all?

Colonel GOWEN: In the first instance, they are sunk to the level of the water. Here are five shieve blocks, with a fall to this winch, and the chains are drawn as taut as possible. Then, the pumps are set at work, and if there is more strain on this chain than on that, the caisson comes up sideways, and gives to the other chain an equal strain.

Captain HORTON, R.N.: Would you be kind enough to describe the diving apparatus that you used?

Colonel GOWEN: I used several systems of diving apparatus. I used a diving apparatus that was constructed by Messrs. Siebe, and also one by Messrs. Heinke. I found that which was constructed by Messrs. Seibe's far superior to the other.

Captain HORTON: Both of them with helmets?

Colonel GOWEN: Both of them with helmets. I had about 150 naked divers! they were at work getting the anchors and chains from the boom across the harbour, which was a very difficult process, because this boom was made of ships' masts, which were clamped together with chains. Then there was a timber put over them, strapped over again with chains, and then the whole was solidly bolted together. The whole boom was nearly a mile long. We had to blast it. Then the chains to which the anchors were attached were also strapped round. The Russians took the greatest precautions in that respect for fear the allies might go in and disengage the chains, so as to allow their vessels to enter the harbour.

Sir EDWARD BELCHER: With regard to the boring of the *teredo;* as a naturalist, I may tell you that I possess all the different shells of the perfect animals that make these holes. They are not all of the *teredo* species. A great number of them are *pholas* and they work behind a shield. In my own vessel, on the coast of Africa, in six weeks, they bored through a plank of two inches. I have most splendid specimens, much finer than any the British Museum possesses. But in the cases of the *teredo;* the *teredo* works, and carries its shelly case with it, all the way through. I have a *teredo* shell about that length (23 inches long, by $1\frac{3}{8}$ diameter), with a thickness of one-sixteenth of an inch on its whole length; so it is a solid creature, in fact. The *pholas*, in the case of very large shells, will bore through what no knife or tool, unless it is of very superior steel, will touch. There is one of the tribe that commences as a living gelatinous animal, and ends positively as a solid piece of calcareous matter which no iron tool will touch. If any person would like to see the specimens which I have, I would gladly lend them to the Museum of this Institution.

Sir FREDERICK NICOLSON: I might just say a few words more. Colonel Gowen has alluded to the "Missouri." I happened to be at Gibraltar shortly after that vessel sunk. I was very much struck with the extraordinary diving capabilities of the Greek divers employed on that vessel. They did some anchor work for me. They used to sling anchors in a most wonderful manner, in ten or twelve fathoms. I was assured that the head man had brought up a sponge from thirty fathoms. I think this fact is worth mentioning, as a proof of the extraordinary capacity these men have for diving.

Captain FREMANTLE, R.N.: Perhaps Colonel Gowen will give us a little more information about the size of those caissons?

Colonel GOWEN: Their capacity was about 5,000 tons. They were 100 feet long, 65 feet in width, and 22 feet in depth. An open trussed girder frame, you observe there. There were six, running fore and aft, in order to give rigidity to the structure. Iron is far superior to wood; but I could not get iron there, and I was obliged to go up into Poland. I was two years in getting timber floated down the Dneiper, and then I was obliged to have it sawn into planks. I think I consumed 1,600,000 feet of timber. That was all done by hand-work. The timber framing

being 16 inches square, was, of course, hewn out. But the outside planking was invariably 6 inches thick. That was all sawn by hand, which was a very slow process.

The CHAIRMAN: Did the large establishment at Nicolaief give you no assistance?

Colonel GOWEN: That large establishment was not in existence then. Just before the war, the Russian Government had purchased the largest saw-mills in the world, and the vessel was ready to sail down with the machinery, and was at Gravesend when the war broke out. Your Government seized those saw-mills, and they were put up at Woolwich. Since then a saw-mill has been erected at Nicolaief. I think they were nine years in constructing the building.

Dr. EDIS: May I ask how you worked the chains?

Colonel GOWEN: In the first instance, I proposed that the chains should go through the centre. As soon as the chains drew taut, they came against the side of the vessel, and it brought the two caissons necessarily together; it was impossible to separate them. Then, I had large cast iron wheels upon pedestals at one end of the vessel, over which the chain passed; and to counterpoise the weight that was suspended there, I had water introduced into the after-compartment. This indicated the lifting power.

The CHAIRMAN: I am sure that the meeting will join me in thanking Colonel Gowen for the very clear and instructive lecture that we have had. So much information could not have been given in a clearer manner than we have had the pleasure of hearing this evening. I can only hope that others external to us, may be influenced in favour of his system of raising vessels, and that he may succeed in his endeavours to get a company up. I should like to explain to Colonel Gowen that, although there is a small audience here to-night, owing to the little notice that was given under the circumstances, yet, as all that is said here appears in our Journal, he will understand that his paper will be widely read, because the absent members are fully alive to the value of the proceedings which take place in the theatre of this Institution. We are much obliged to you, Colonel Gowen.

LECTURE.

Friday, May 21st, 1869.

REAR-ADMIRAL SIR JOHN C. D. HAY, Bart., M.P., F.R.S., in the Chair.

THE MARTINI-HENRY RIFLE (THE NEW MILITARY BREECH-LOADER).

By Captain VIVIAN DERING MAJENDIE, R.A., Assistant Superintendent Royal Laboratory, Woolwich.

THE subject on which the Council of this Institution has honoured me with an invitation to lecture this afternoon, is the Martini-Henry rifle, the proposed future arm of the British soldier. It will be necessary, however, in order to make what I have to say respecting the contemplated introduction of this arm intelligible, to take you back a little way in the history of the subject, and to recall something of what I stated in this lecture-room two years ago. We can only reach the arm of the future, in fact, by glancing at the past, and by making good our position with regard to the present. Of the past, however, not much need now be said. Still, there is something more about it than a mere archæological interest; and one might well refer to the curious fifteenth and sixteenth century prototypes of our nineteenth century breech-loaders, with a practical purpose—with the purpose, namely, of realizing the fact that, in those early days, the earliest days of fire-arms, there was an instinctive striving after a development which has only touched its accomplishment now, four centuries later. If, carrying our reflections on this point a little further, we endeavour to explain the long-delayed fruition of these hopes and efforts, we shall find such explanation partly in the imperfect state of mechanical and scientific knowledge, and partly in the absence of a thorough perception of the necessities of the case, due to the simple fact that the necessities had not yet arisen. Then eventually had come the clearing away of the obscurity which beset the subject, the gradual solution of its difficulties, the sort of revelation which told us that the objections to cartridges containing within themselves the means of ignition, had in reality no force, the enlightened appreciation of the military advantages of breech-loaders to which this revelation gave rise, and which otherwise followed as a natural consequence the development which small arms had received in every other direction: finally, the stimulus

which the question derived from the actual performances of a certain very famous, but really indifferent breech-loader in actual warfare, and its immediate quickening into vigorous life. What is most noticeable about the past, and what I chiefly wish to insist upon is, that at no time was the subject altogether devoid of a certain vitality. In the early days of fire-arms, breech-loading was rather the rule than the exception. Thus, a French writer on the arms exhibited in Paris in 1867 divides the present breech-loaders into six classes, five of which classes, he says, are represented among the guns of the sixteenth and seventeenth centuries; while the comparison between the earlier models and the later reproductions is not always, as far as simplicity is concerned, on the side of the more modern gun. My own impressions, derived from a careful examination of the arms at Paris, accord, I am free to admit, very fairly with those of M. de Brughat. Then, considerations and difficulties of all sorts crushed breech-loading out of seeming life, and for a long lapse of years it so remained. But it was sleep, not death. And when the proper time came—the proper time, mark, as we shall see presently,—the epoch which arrived in the process of the natural development of firearms—the trumpet of war sounded twice, quite distinctly, once in Denmark and again in Bohemia, ringing out in each case no faltering note, but speaking to the irresistible success of a weapon too long neglected, and, like the Prince's horn in the pretty fairy tale, awakening the nations, and resolving their dreamy contemplations into daylight realities.

There, then, running through the dark years of distant ages is the silver thread of the subject, which however often hidden by the woof, patience still may follow—the thread which binds us, I believe, directly, however lightly, with a period some four centuries distant.

The explanation of this connection I have already indicated when I spoke of the instinctive yearning for the employment of a breech-loading system. For, in truth, it amounts to an instinct, and no man would naturally elect to introduce his charge at the muzzle, unless the pressure of difficulties, or habit, or prejudice, drove him to do so, and unless he saw no sufficient reasons to induce him to resist and overcome that pressure. The explanation of the temporary abandonment of breech-loaders I have also indicated in what I have said of the actual presence of these difficulties, and in the actual absence of an adequate appreciation of the merits of the system and of the necessity for its introduction. It is, perhaps, worth while to notice that the revival took place most vigorously in the country which had most developed her mechanical gun-making industry, viz., in America, because the fact bears upon the close relations which exist between breech-loading and the mechanical art. It seems, also, worth while to notice that, despite her mechanical advantages—or, perhaps, I should say in consequence of those advantages—America did not strive in the direction in which so many inventors of breech-loaders have unfortunately laboured, only to meet with disappointments, and to find themselves in the end obliged to retrace their steps. Speaking generally, it may be said that America made no attempt to throw the work of closing the breech upon the mechanical fit of that part

of the gun, notwithstanding the skill and ingenuity which she might have brought to bear upon the problem. Americans were, indeed, too sound mechanics to attempt that which was mechanically unsound. Thus, we find the self-consuming cartridge generally rejected by the Americans, and the non-consuming metal cartridge, *cartouche obturatrice*, as the French appropriately call it, generally employed.

Thus we reach the point of the practical revival of breech-loaders, which took place about three or four years ago.

You will, perhaps, recollect that after the Dano-German war, General Russell's Committee, which Lord de Grey had appointed to report upon the advisability of arming the infantry, either in whole or in part, with breech-loaders, did report in July, 1864, that it would be desirable so to arm the British soldier; this however, without reference to any particular system. Then, how was this recommendation to be applied? A decision, the wisdom of which is, I think, indisputable, was come to. It was decided to endeavour, in the first place, to utilize the existing store of muzzle-loading arms by converting them into breech-loaders, proceeding, meanwhile, to the larger question of the selection of a totally new arm for future manufacture. This decision not only recommended itself because of the saving of time in the re-armament of the British soldier, which it tended to effect, while it also afforded time for the leisurely consideration of the more difficult question of the adoption of a new arm, not only because of the economy of using up the existing arms, and of the advantage to be derived from the acquisition in the course of the conversion inquiry of a vast amount of experience, likely to be invaluable in the future and fuller inquiry: not only, I say, did the decision recommend itself on these grounds, but it was based upon a very sound and by no means common perception of the real elements of the problem. It proceeded upon the sound principle of separating the shooting part of the gun from the loading part. We had a gun, which, as far as shooting went, was very accurate, which some will even now contend is quite accurate enough for the rough and ready shooting of actual war. What we desired was to multiply its rate of delivery to a point consistent with the requirements of the age. We shall see presently that the same principle of separation has governed the course of action of the Breech-loading Committee, and most properly so. The question of accuracy is so far independent of the question of facility of loading—the character of the fire is so distinct a thing from its rapidity, as to demand separate investigation. And the two questions have therefore received separate investigation throughout the whole of the inquiry; first, in the decision to convert the Enfield by fitting it with a breech-loading arrangement; second, in the decision, which I shall have presently more particularly to notice, to carry out the barrel and breach-loading tests independently; the embodied results of this course of action we see, first, in the Snider-Enfield; second, in the Martini-Henry.

Well, gentlemen, I need not trouble you, I think, with the history of the Snider-Enfield.

I ventured two years ago in this room to predict a successful career

for this arm, a prediction to which I am justified, I think, in looking back with satisfaction. The arm has now been tried and acquitted itself well under the most extreme climatic influences, and it has won its spurs on actual service in Abyssinia. The Breech-loading Committee say that the Snider-Enfield is, "without doubt, a most efficient military weapon." Indeed, so little likely is this opinion to be disputed on the present occasion, that it seems to be unnecessary for me to press upon you, as I might do, the weight of two years' accumulated experience in favour of the arm. You may, perhaps, be interested in seeing a rifle which has fired, more rounds, probably, than any other rifle in the world. Here is a Snider-Enfield which has fired, under my superintendence, 72,000 rounds, actually without requiring any repair, and which is still perfectly serviceable. Here, too, is a target of 12 inches, which was made with this rifle only four days ago. So also of the cartridge, upon which the success of the system, in a great measure, hinges. That is now generally admitted to be an exceedingly satisfactory cartridge. With the exception of one pattern (No. V), in which, with a view to economy, the amount of material, and, consequently, the strength had been, as the event proved, unduly reduced, these cartridges have admirably fulfilled the requirements of the service; and not only this, but the construction has been finally adopted by the Committee as that best suited for a military cartridge. In short, while the arm itself is to be replaced by a weapon of superior efficiency, the cartridge (I do not refer to the bullet) remains substantially unchanged, retaining its position as the service cartridge *par excellence*. I should, perhaps, mention, that for exceptionally damp climates of fluctuating temperature, such as India, it has lately been shown to be necessary to adopt some extra internal protection, and this thin paper lining, with a thick intermediate coating of varnish, has been recommended for this purpose, to prevent the action of the powder upon the brass: also the bullet is to be varnished to prevent corrosion. To avoid the inconvenience of having two ammunitions for the same arm, it is proposed to apply this protection to all cartridges for future manufacture, for whatever climate.

I think, therefore, that we may fairly say that the intentions of those who decided upon the conversion of the Enfield rifle, and the hopes of those who recommended the adoption of the Snider system of conversion and the Boxer cartridge, have been most satisfactorily fulfilled. Every one of the contemplated advantages has been satisfied. The re-armament has proceeded so rapidly, that over half a million rifles have been converted, and our regular troops of all arms, the Navy, Marines, and a proportion of the Militia have been furnished with breech-loading rifles, in addition to the establishment of a sufficient store to meet emergencies. We have also been afforded two years' breathing time in which to work out the question of the selection of the new arm. The conversion has satisfied the condition of economy in a high degree, having at the comparatively small cost of under 20*s.* an arm, given us a weapon of great efficiency, and one of a character which, when the new arm is introduced, may be confidently passed on to the reserve forces. Finally, it has afforded

us an opportunity of accumulating a vast amount of experience—how much and how valuable, those only who have closely watched the development of the question are really able to say. Our ideas on the subject of breech-loaders have during the inquiry clarified and broken up; inchoate opinions have assumed a coherent form; false principles have been rejected, sound ones have been affirmed. Briefly, we have mastered, I hope, the grammar of the subject. Think, for example, what it is to have definitively disposed of so-called self-consuming cartridges; to have made a deliberate selection of central-fire in preference to either of the other modes of ignition; to have decisively driven pasteboard cartridges out of the field. Think again what it is to have affirmed, as the Breech-loader Committee have done in very precise terms, and in a very practical way, that breech-loaders which depend upon the cartridge to close the breech should not at the same time depend upon the cartridge for their ultimate safety—should not, that is, be liable to be blown open in the event of any failure in the obturation. I say this was practically affirmed by the Committee in their decided and summary rejection of all arms which, like the Snider, have a breech which is not secure in the event of an explosion. And this opinion has been practically adopted by the Government in the latest pattern of Snider rifle (III.), of which I have a specimen now in my hand, and which is one of a few thousands which it has been found necessary to manufacture, to prevent the store from being exhausted. In this arm, which is not a conversion, but a new rifle with a steel barrel, the breech block is fitted with a locking bolt of a simple character, to prevent it from being blown open. Some casualties of this sort have occurred—no very heavy percentage, but sufficient to illustrate the disadvantage of a non-safety breech. Just as I object to depending wholly upon your gun for your gas check, so do I object to depending wholly upon your cartridge for your safety. The one principle is an extravagant reaction on the other, and equally false. It is both economically and mechanically false to depend for safety wholly on your cartridge. Economically, because if you have a safety breech, you may confidently employ a weaker, and therefore a cheaper, cartridge—such, for example, as that pattern (No. V) of which I have spoken as having had to be abandoned because of this risk of occasional casualties involved in its use. Mechanically false, because the success of your system is then contingent upon a niceness of combination, a perfect accuracy of manufacture and material in arm and ammunition, which it is, I should say, impossible invariably to secure, or which can only be ensured at an outlay which we are not justified in incurring if we can possibly avoid it. And in this instance we can avoid it, avoid the necessity for such extreme accuracy of manufacture, avoid even the remotest risk of accident, by the simple adoption of the principle which has now been applied to the Snider, which has greatly improved the arm, which has remedied its only observed defect, and which, no doubt, will henceforth be generally accepted.

So much for one branch of the breech-loading question—the temporary provision for present use of an efficient arm, and of the light

which has meanwhile been thrown upon the whole subject. The other branch is the selection of a new arm for future manufacture. You will perhaps, say, If the Snider is what you have stated it to be, if it is really "a most efficient military weapon," why supersede it? To this I answer, There was no foregone determination to supersede it at all. If the Snider could hold its own against the numerous improvements of an active age, well and good; the Snider would in that case properly remain the service arm of the British soldier. But was it reasonable to expect that the ingenuity, which for some years has been concentrated upon the production of a good breech-loader, could suggest no improvement in an arm of which the breech-action (which, moreover, was hampered with the condition of its application to existing arms), was adopted in 1866, before the period of unexampled activity in this direction; and of which the shooting apparatus had been adopted in 1853—16 years ago? With regard to the last point, I cannot do better than read a passage from a report of the Ordnance Select Committee on systems of rifling, dated 26th November, 1862:—"The Enfield rifle was introduced into the service at "a period when comparatively limited experience had been acquired "in this country with respect to elongated rifle bullets, and when no "fixed and generally accepted principles had been established as to "rifling small arms. The gun trade were themselves much divided "in the opinions they held, and those that were accepted as the best "were founded rather on speculation or arbitrary rules, than on ex-"perience or scientific reasoning. Under such circumstances, the "highest credit is due to those who, selecting and combining such "proved advantages as then existed, produced a weapon, which not only "at that time was, but is still (1862) believed to be superior to any arm "adopted by other countries. Since the year 1853, however, not only "has the attention of scientific men been directed to the improvement "of rifled fire-arms, but the value of their theories has been tested both "at home and abroad, by an amount of careful experiment which "exceeds that of any other period. The result of these labours has "been the production of rifles of greatly increased precision at long "ranges, a point of considerable importance when the improvements "in modern artillery are taken into consideration." Thus the inquiry was instituted not, be it understood, in order to supersede the Snider-Enfield, but in order to discover if, as was reasonable to expect, such supersession was necessary. For this purpose, the Snider rifle and its ammunition were taken as standards, to which any system putting forward claims to acceptance must be not merely equal at all points, but which they must excel. In order to bring together all that there was of new and good, ingenious and serviceable in military fire-arms, the War Office authorities on the 22nd October, 1866, cast a net weighted with heavy golden prizes and opportunities of distinction, in the shape of an advertisement addressed "to gunmakers and others." The meshes of this net were so contrived, that anything smaller than the Snider, any arms of inferior merit, would soon slip through, while any of equal or superior importance would be retained to be afterwards fully tested, until finally a few choice specimens

should remain, from which the final selection might be made. To award the prizes, a special committee was appointed, consisting of Lieut.-Colonel Fletcher (Scots Fusilier Guards), Lord Spencer, Captain Mackinnon (3rd Regiment), Captain Rawlins (48th), and Mr. Edward Ross.

In the first instance 104 rifles were submitted, of which no less than 67 failed to comply with the terms of the advertisement, and were, therefore, as far as the prize competition went, out of the race. Eventually, by a process of elimination which need not here be described, the 37 arms which were eligible to compete, were reduced to 9, which were recommended for further trial, each of the inventors being paid £300, and required to furnish for experiment at Woolwich 6 arms, in strict conformity with the specimen arm submitted, with 1,000 rounds of ammunition per arm, within four months after date of demand. It is unnecessary to dwell upon the various incidents, often ludicrous, which relieved the tedium of this first stage of the inquiry, incidents which oscillated between the excess of caution exhibited by the inventor, who point blank refused to run the risk of firing his own gun, and the excess, in the other direction, of misplaced confidence, which nearly proved fatal to the designer of a safety bolt, which exhibited its efficiency, by allowing the breech to be blown violently open in the inventor's face.

The nine arms selected to compete for the prizes, were the Albini and Braendlin, the Burton (No. 1), Burton (No. 2), the Fosberry, the Henry, the Joslyn, the Martini, the Peabody, and the Remington.

It is not, I think, necessary to follow the prize competition very closely. It has little practical interest now. The object, as far as the public was concerned, was fulfilled directly the arms which this competition was instituted to attract, had been brought together. It was of course just possible, that among the competing arms there might be one so satisfactory at all points as to warrant its adoption into the service; but as this proved not to be the case, it would only be wasting time to dwell upon this stage. Suffice it to say that the broad results were as follows:—The competition commenced on the 29th October, 1867, and the conclusion was reported on the 12th February, 1868. The whole of the nine rifles fell short of the qualifying figure of accuracy, and in most instances the standard was not reached in other respects. Therefore the first prize of £1,000 was withheld altogether.

The second prize of £600 for the best breech-mechanism was awarded to the Henry rifle, which arm, it is fair to observe, most nearly attained all the required qualifications. Indeed, this rifle was disqualified for the £1,000 prize, chiefly on account of non-compliance with the condition of employing only pure beeswax for the lubrication. The fortunes of one other arm in this competition must be noticed. The Martini not only failed to receive a prize, but was placed seventh on the list. Naturally the question will occur to you, How was this? How is it, that while the Henry breech-mechanism obtained the prize in this first trial, the Martini breech-mechanism is now finally preferred? Is there no contradiction here? None whatever.

The explanation is simple enough. The Martini, I quote the words of the Committee, "failed entirely, owing to the defects in ammunition." Mr. Martini had submitted copper rim-fire cartridges with his gun, which burst repeatedly near the rim, and exhibited the arm in so unfavourable a light, that it was impossible through the thick cloud thus established, to recognise its merits. The lesson to be derived from this is an instructive one. In a few words, it amounts to this: "A breech-loading arm stands or falls in a great measure by its ammunition." Give the best gun in the world a bad cartridge, and the gun must prove more or less of a failure—more or less inferior to arms of inferior intrinsic merit. The cartridge is in fact a part, and a very important part, of the breech. A decided failure in this part practically determines the failure of the whole, as conversely the success of the cartridge determines in a large degree the success of the gun. When, as in the case of the Snider, the breech is a non-safety breech, the failure of the cartridge will entail explosive escapes, dangerous consequences, in fact, the total failure of the system. When the arm has a safety-breech, like the Martini, the consequences of a decided failure of the ammunition fall short of this. They are not dangerous, but merely disastrous to the system. But this fact is rarely recognized, and the cartridge is scarcely ever credited with its proper share of the success. In the accounts of the Wimbledon competitive shooting, for example, even in the Report of the National Rifle Association, the cartridge used with the successful breech-loaders is not so much as named. Thus, the gun-competition was concluded against the whole of the arms, as perfect systems; but in favour of the Henry, considered merely as a breech-loader.

Then there was the cartridge-competition, for which a very few words will suffice. The Government Boxer ammunition was not allowed to compete for the prize; and the same construction of cartridge adapted for a small bore calibre had not been formally submitted, although it was successfully employed with many of the competing arms. Of the 49 sorts of cartridges formally submitted, 48 were considered unlikely to fulfil the conditions of the War Office advertisement, which had prescribed, that they should be "as little liable to injury by rough usage, damp, and exposure in all climates as the Boxer cartridge; also as little liable to accidental explosion as the same cartridge, and as capable of being manufactured in large quantities, and of uniform quality." This left but one cartridge in the competition, that which had been submitted by Mr. Daw, and which resembles the service cartridge in having a case of thin coiled brass, but which, unlike the service cartridge, is secured by soldering the edges, instead of cementing them together with paper, and is fitted into a base of the construction generally known as the "Pôtet," and which consists of sheet brass stamped into the form of a flanged cap. To this cartridge, which appeared to the Committee to fulfil the prescribed conditions, the £400 cartridge prize was awarded. But in the course of the trials, it was proved that the Government cartridge-case, which, for the reasons I have stated, was not deemed eligible to compete for the prize, was the best; and the Committee accordingly decided to use it

exclusively in the subsequent experiments. Thus the results of both gun and cartridge competition were destined to prove abortive. A gun which satisfied the required standard of excellence was not forthcoming; the breech mechanism which received the prize has since been adjudged not to be the best; and the prize cartridge is pronounced inferior to one not in the competition.

Still, this stage of the enquiry was not thrown away, if we look only to the object which it had satisfied of collecting a number of arms, to the experience which was acquired during its progress, and to the clearance of the subject, which was thereby effected. Directly we leave the prize competition it is like emerging from a tangled thicket, in which trees of all sorts are growing crosswise, in which all is confused and obscure; and one can imagine the relief of the Committee when they found themselves once again in the free field of experimental inquiry, unhampered by this restriction and that, no longer forced to shut their eyes to possible excellencies in a system because the inventor had neglected to conform in some minute particular of weight or length to a prescribed standard, no longer compelled to decide on the comparative merits of arms which had not one feature of calibre, weight of charge, nature of cartridge, &c., in common, by which they could be compared.

It was now possible for the first time to bestow due attention upon several promising systems which had been, in the first instance, disqualified. It was now possible, also, to pit one mode of rifling directly against another, to measure with some confidence the advantages of various breech mechanisms, to discover, in short, what each system taken at its best could do, and which was capable of reaching the highest point of accomplishment.

In order to do this properly, it was necessary to reduce the various systems to one common denomination; and, as a preliminary measure, it was resolved to separate the question of barrel or shooting from that of breech action or loading. On this decision I have already commented by anticipation, and need now only repeat my opinion, that it was a thoroughly sound and wise one—the only course, in fact, calculated to ensure the production for the use of the British soldier of the best procurable weapon.

By way of deciding upon the elements which should furnish the common denominator for the barrels, evidence was taken from gentlemen of the highest qualifications and experience in matters connected with small arms. Among those who gave evidence I find the names of His Royal Highness the Duke of Cambridge, Lieutenant-General Hay, Colonel Haliday (Inspector-General of Musketry), Colonel Dixon, Colonel Boxer, Colonel Halford, Professor Abel, Messrs. Whitworth, Lancaster, Westley Richards, Rigby, Burton, Kerr, Henry, &c.

The evidence was sufficiently concurrent, and the experience of the Committee had been already sufficiently clear, to enable a decision to be come to on the following points:—With regard to calibre it was resolved to adopt a ·45″ bore, in preference to the large service bore of ·577″, or the intermediate bore of ·5″, a point, on which the Committee were further fortified by the authority of no less than four

previous decisions. The weight of bullet was fixed at 480 grains; in construction it was required to be solid; a charge of 85 grains of powder was adopted. The length of the barrel was fixed at 35 inches; its weight at 4 lbs. 6 oz.: and by preference, although not absolutely, steel was adopted as the material. The lubrication was required to be pure beeswax, as that best adapted to withstand variations of climate, long keeping, &c.

Of course, the wisdom of each of these conditions is open to discussion; but it must be recollected that each of them had been very fully discussed by experts, and the Committee were guided in their selection by the preponderance of opinion, without requiring or expecting absolute unanimity. Where it was impossible to come to any decision without begging the question presented for solution, or arbitrarily cutting the knot created by conflicting testimony, as in the case of the nature of rifling, the method of stocking, the quality of powder, &c., no conditions were imposed, and each competitor was free to make his own selection.

For the purpose of making the comparison between barrels fulfilling the above conditions, but differing where differences were necessarily permitted, it was desirable to adopt temporarily some one breech action, and to use for the whole the same cartridge case. The Snider-action was at first decided upon; but as its use would have entailed some delay, it was eventually decided to use the Henry breech-action (which, as we have seen, had already gained the £600 prize), and the Boxer cartridge. A circular letter was, on the 9th March, 1868, sent to the representatives of the most successful and best known systems of muzzle-loading rifles, embodying the above conditions and inviting their assistance. With one exception, the assistance thus asked for was promised, and the following gentlemen undertook to supply barrels for the purpose of the competition:—Mr. Whitworth, Mr. Westley Richards, Mr. Lancaster, Mr. Rigby, and Mr. Henry. Colonels Dixon and Boxer represented the Enfield system of rifling. I should be largely exceeding the limits of this lecture were I to attempt to describe in detail the distinctive features of the six barrels, the rates of twist, nature of rifling, &c.; and as I do not wish to go into figures on this occasion I shall not attempt to do so. To the six ·45″ bore guns, a ·5″ barrel (Enfield rifling) was added for the purposes of comparison. The competition became, ere long, reduced to four barrels, viz., the Enfield ·5″ bore, and the Henry, Whitworth, and Enfield ·45″ bores. But before the 1,000 yards range was reached, only three arms remained in the race, the Henry and the two Enfields. Of the two ·45″ inch bores, the Henry system proved considerably superior in accuracy to the Enfield; and as it had already shown that its trajectory was as flat as that of any of the other ·45″ bores which it had excelled in accuracy, while it did not exhibit any liability whatever to foul with continued firing, the Henry rifle became established as the best of the small bores, on the two important points of trajectory and accuracy.

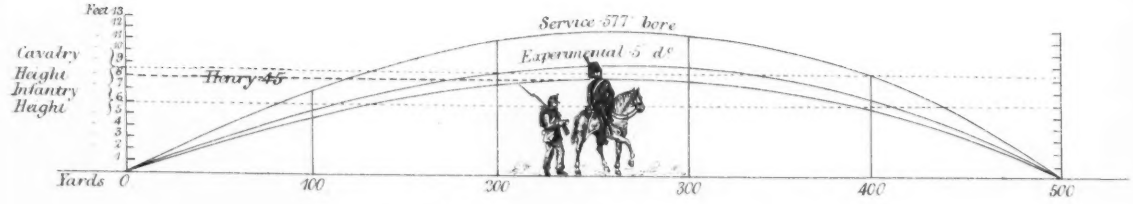
Here, however, it is only fair to observe—and I wish to do so with all possible emphasis—that the inferiority of the other systems in this particular competition proves nothing as to their relative abstract

merits or capabilities. Several of the competitors represented that the time allowed was too short to enable them satisfactorily to work out the problem of obtaining good shooting from a barrel hitherto only used for muzzle-loading arms, and now to be used as a breech-loading barrel. Indeed, one inventor expressed an opinion, which has certainly been contradicted by the result, that no good shooting could possibly be obtained under the conditions laid down. Therefore, it may reasonably be urged that this result constitutes no substantial triumph of one system over another. But this it does appear to establish, that of the various systems, the Henry is, at the present time—or was, a few months ago, when these experiments took place—the one which best fulfilled the conditions which, by a preponderance of competent opinion, are held to be requisite, or best adapted, for a military rifle. And the decision not admitting of indefinite postponement, but being a present necessity, no course was open but to accept the Henry combination as the best of the ·45″ bore systems, without reference to the possible developments which the inventors of other systems might be sanguine of effecting hereafter at their leisure. It will be time enough to return to the other systems when they can press fresh claims for consideration. But besides beating the rival ·45″ bores, the Henry was required to establish also its superiority to the ·5″ bore, and to the service ·577″ bore which had been taken as a standard, before it could be recommended for adoption. I find it very difficult to convey an idea of the results of this part of the competition without going into figures, which would be dry and difficult to follow. Expressing the figures briefly in words, I may say that in trajectory, in accuracy, in initial velocity, and in penetration, the Henry proved superior to the two arms placed in comparison with it. As regards trajectory, the annexed diagram (Plate xix) and table show the advantage of the small bore, and illustrate for purpose of comparison, that a cavalry soldier would be nowhere safe against a Henry rifle fired at a 500 yards' range, while with the ·5″ bore there would be safety for 104 yards in the centre of the range, and with the service bore for 262 yards, or more than half the distance, during which the bullets would be flying over his head. As regards accuracy, the superiority of the Henry to both rifles, especially at the longer ranges, is very marked. The initial velocity of the Henry (with Curtis and Harvey's "No. 6" powder) is 20 feet a second higher than that of the ·5″, and 110 feet higher than that of the Snider.

TRAJECTORIES of Henry, ·45″, Experimental Enfield, ·5″, and Snider-Enfield, ·577″ Rifles.

	Safe Distance for Cavalry.	Safe Distance for Infantry.	Greatest Height of Trajectory.	Initial Velocity.
	Between	Between	Feet.	Feet.
Snider, ·577″.....	138 and 400 yards	92 and 438 yards	11·9	1362·7
Experimental Enfield, ·5″	221 and 325 „	123 and 406 „	8·9	1342·7
Henry, ·45″.....	Nil	139 and 396 „	8·1	1252·8

TRAJECTORIES
of
SERVICE ·577", EXPERIMENTAL ·5" & HENRY ·45" BARRELS



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The penetration trials were very interesting, giving a penetration to the Henry of 14½ elm planks, ½″ thick, as against 8½ with the other arms; and a penetration through iron plates of over ½-inch thick at 200 yards, while the service arms failed at 100 yards. Gabions and sap rollers were pierced by the Henry; rope mantlets by the Henry up to 350 yards, while the Snider failed at 50 yards. (For particulars of penetration trials, see Appendix A.) Finally, when fired into the carcass of a horse, the Henry rifle was certified by a veterinary surgeon to have produced the most formidable wounds, smashing bones against which the other bullets flattened, or from which they glanced off. Of course, these results are to be, in a large degree, credited to the hardened bullet used by Mr. Henry. The amount of allowance required for wind is much less with the Henry than with the other two rifles, only about half as much at 1,000 yards in a fresh wind. On one point the larger bores had an advantage, viz., in a reduced length of cartridge; but as the weights and cubical measurements of the three ammunitions were as nearly as possible equal, and as the rapidity of fire with the longer cartridge—one of the points on which the difference may be expected to be felt—is considerably greater than that of the service arm and ammunition, and its power of resisting rough usage is not appreciably less, this element of inferiority, if such it is to be called, may be safely ignored, as of no real practical value.

The following table gives the lengths and cubic measurements of the three ammunitions :—

LENGTHS and Cubic Measurements of Boxer Ammunition for ·45″, ·5″, and ·577″ bores.

		One packet of 10 rounds, packed as for service.
	Length.	Measurement.
·45″ cartridge	3·75 inches	11·481 cubic inches.
·5″ „	3·29 „	11·725 „
·577″ „	2·45 „	11·583 „

Thus it came about that the Henry rifling was, in the end, accepted as the one "most suitable in all respects for the requirements of the service." It is now time, however, to state what the Henry rifling is. This diagram shows it (see Plate xx). It is a polygonal system, of nine or seven sides, the latter having been adopted in the new arm as slightly less costly to manufacture and equal in other respects; the angles are broken by ribs, which create re-entering angles, the inscribing circle tangential to the ribs being described with the same radius as the inscribing circle tangential to the plane sides. The twist is 1 in 22, uniform. The durability of this rifling is sufficiently established by the fact, that the barrel which I hold in my hand has fired as many as 30,000 rounds

without any signs whatever of deterioration. Finally the expense of manufacture of barrels on this system is not greater than that of other ·45″ arms.

Before quite leaving the barrel question, I should make a few remarks on the general question of accuracy for military arms. I have always held a strong opinion that it is unwise to sacrifice to exceeding accuracy of shooting, other qualifications. If you cannot obtain such accuracy without serious loss, without incurring a danger of fouling, without unduly lengthening or strengthening your cartridge, without unduly increasing your strain, then assuredly the extreme accuracy should be thrown overboard. But it will hardly be contended that if without any such loss you can secure an exceedingly accurate rifle, you should not secure it. For ordinary purposes of warfare this great niceness of shooting is, I admit, not necessary. But if we go back to first principles, and look to the reasons which recommended the supersession of smooth bores, that, namely, we might strike an enemy with the greatest amount of certainty and at the greatest distance, then undoubtedly it will appear that accuracy is, *cæteris paribus*, a distinct advantage. A watch, as I have said before in this room, will serve ordinary men as well as a chronometer, but if for the same cost and without any loss of general efficiency, you can secure a chronometer, then unquestionably the chronometer is to be preferred. And this it seems is exactly what has been done in the case of the Henry. Not only does the adoption of this accurate system entail apparently no loss, but it secures to us some very important advantages, as flatness of trajectory, increased penetrative power, comparative freedom from the effect of wind. Therefore, if we take a bold, comprehensive view of the question in all its bearings, it will appear, I think, that the Committee exercised a sound discretion in selecting this rifle for the use of the British soldier. Only, the instruction of the British soldier in the use of an arm of precision must now be developed in proportion to the advantages which that arm is calculated to confer; and above all he must be taught that because he has a long range rifle it is not *necessary* for him to employ it invariably at long ranges—that, as a *general rule*, it is undesirable that he should do so. If, however, you can so improve him as a shooting machine as to enable him to do with the Henry at 800 or 1,000 yards, what he would have done with the Snider at 500 or 600 yards, then the adoption of the more accurate arm will be all gain.

Having thus secured a rifle of superior precision, we have now to inquire in what way that rifle should be loaded. That it must be loaded at the breech is admitted. But, in deciding upon a breech action, we must not fall into the too common error of regarding the question as one of mere rapidity. We have to look also to the durability of the breech mechanism, its simplicity, its safety, its ease of manipulation, its non-liability to injury by wear, exposure or rough usage; and while there are many systems which satisfy one and more of these conditions, there are comparatively few which satisfy all. Still, the number of promising breech mechanisms is sufficiently great to warrant, and the exigencies of the military service are sufficiently imperative to

demand, the application of tests of great severity. Assuredly the tests applied by the Committee did not fail in this respect. Their general course was as follows:—The arms were carefully examined, and then 20 shots were fired for rapidity, sand was thrown over the actions both open and closed, and the rifle fired without any cleaning beyond what could be done with the hand. Cartridges purposely damaged to ensure an escape of gas were fired to test the safety of the arm with imperfect ammunition. Finally, each gun was put through a test of long continued firing, being allowed to rust by exposure at intervals between the days of firing, and having water poured into the breech to aggravate its sufferings.

The arms carried forward for this competition were 65 in number, viz., the nine arms which had competed for the prize, eleven arms which had been disqualified for the prize competition, but set aside as entitled to future consideration; and forty-five new arms which had been submitted after the first report had been rendered. I cannot attempt even to name the whole of these arms, still less to specify the grounds upon which one after another was rejected, until there finally remained only ten rifles, as follows:—The Bacon, Carter and Edwards, Kerr, Wilson, Berdan, Martini, Money-Walker, Henry, and two Westley Richards' rifles. Of most of these arms I have specimens here to-day. They fall naturally into two great classes—bolt-guns and block-guns. The first class is represented by the four first named arms; the second by the remaining six.

The bolt-guns were subjected to a special test to demonstrate their liability or non-liability to accidental explosion in the process of closing the breech. It has been urged that the closing of the breech might, in some instances, occasion the explosion of a sensitive cartridge—such a cartridge as may, in a small per-centage of cases, occur in manufacture. To test this, cartridges embodying these exceptional defects were supplied. Some had no safety shoulders on the anvil, some had long anvils, some had short caps, some had an increased quantity of detonating composition. All were more liable than a perfect service-cartridge to accidental ignition, but all represented cartridges which might possibly find their way into the service supplies. Without following the details of this stage of the competition too narrowly, or specifying the failures, sufficiently marked in two instances, I may say that only one gun, the Carter and Edwards, thoroughly satisfied the test. Still there remained with regard to this gun a supposed general liability, not shared, or, at least, certainly not shared in the same degree, by block-guns, to be exploded by the simple impact of the bolt upon the base of an over-sensitive cartridge, and the resulting concussion; and on this account the bolt-system was eventually rejected. It has been said that this objection is a purely fanciful one, and was contrived to meet the pre-conceived views of the Committee. I feel bound emphatically to dispute this statement. I know nothing, it is true, of the pre-conceived views of the Committee, if such existed; I know their views only through the medium of their Report. But this I do know, that the objection is not a fanciful one; and in proof of it, here is a list of 18 cartridges which have actually exploded in the mere process of

handling, gauging, or unpacking, or by a simple fall upon the floor of the factory. (See Appendix B.) Therefore, I admit to sharing with the Committee the conviction that such cartridges, placed in the breech of a bolt-gun, might be liable to be occasionally exploded by the concussion of the bolt employed to drive them home.* The chance is remote, I grant, but that it exists, cannot, looking to the results of our experience, be effectually disputed.

We need, therefore, only follow the fortunes of the six block-guns. Here, I should mention that the breech-mechanisms had been reduced as nearly as possible to a common denominator by the adoption, for the purposes of the trial, of the Boxer cartridge-case, except in the case of the Westley Richards and Money-Walker rifles, which employed special cartridges.

In the rapidity trials, the block guns were ranked as follows:—

		20 rounds in			
1st.	Westley Richards (elevating block)..	1	minute		
2nd.	Martini.....	1	„	2	seconds
3rd.	Henry	1	„	7	„
4th.	Westley Richards (falling block)..	1	„	7	„
5th.	Berdan.....	1	„	10	„
6th.	Money-Walker	1	„	14	„

The sand and damaged cartridge tests were gone through by the whole satisfactorily.

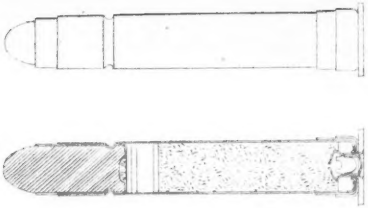
The exposure-test, however, practically reduced the competition to the Henry and Martini-mechanisms, of which the latter gave the better performance, having been found in perfect order at the close of the experiment, while the Henry-mechanism had proved itself, in some slight degree, sensible to the severity of the test. Here it is worth while to notice the difference of the results obtained with the Martini when furnished with a suitable cartridge; the point on which I have before insisted is thus thrown into relief.

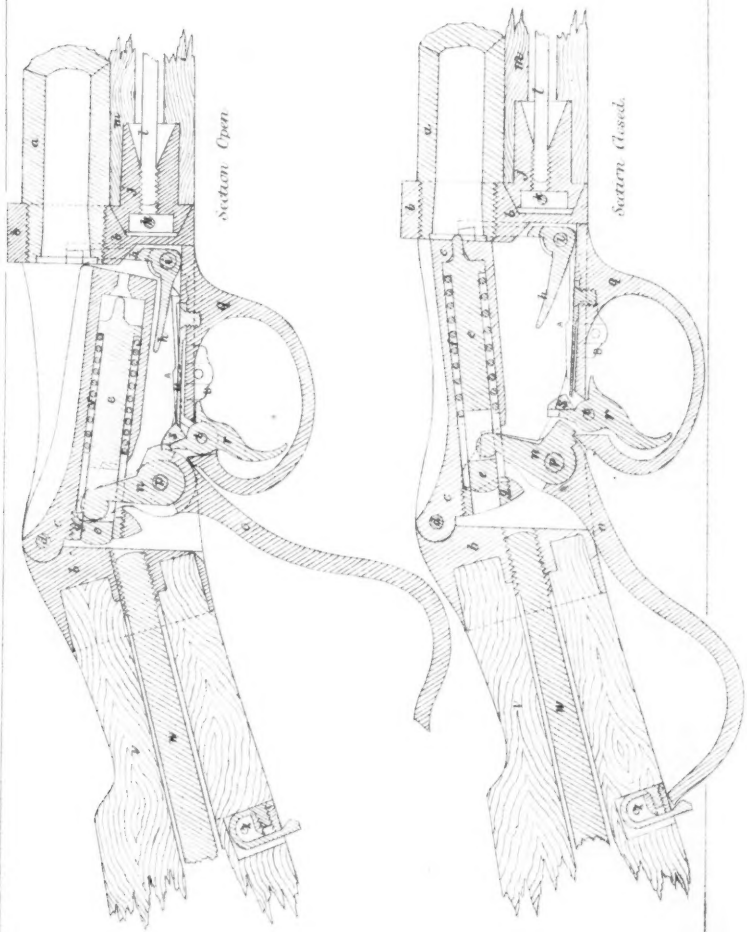
The competition being thus reduced to a match between the Martini and the Henry, a comparison was taken between the two on the essential points of safety, strength, number and simplicity of parts, facility of manipulation, and cost. With regard to safety and strength, both arms appeared to be equal. The number of parts of the latest pattern Martini is 27, as opposed to 49 in the Henry. The Martini, having no hammer, is easier to manipulate; and it was reported to be the cheaper to produce. Moreover, the absence of the hammer was regarded by the Committee as a distinct advantage, while the Henry discovered a possibility (remedied, I am informed, in a later pattern) of placing the cartridge in front of the extractor, and thus temporarily disabling the gun.

The Martini-gun you will perhaps examine more at your leisure after the lecture, and I have here a working section which permits of the action being readily inspected. These diagrams (Plate xx) explain its con-

* The very strong evidence upon this point, given by Colonel Halford, and printed in the Report of the Committee is worth referring to.

Section of
Henry Rifling
45" bore




Section Open
Section Closed.

J. Johnis

struction, which consists, briefly, of a swinging block hinged upon a pin passing through its rear end; the recoil being taken by the shoe. The cartridge is exploded by a direct-acting piston, which is driven by the action of a strong spiral spring within the breech-block. The block is moved by means of a lever to the rear of the trigger-guard. The motion of pushing the lever forward, depresses the block, compresses the spring, and ejects the empty cartridge case. When the lever is drawn back, the block is raised and the breech closed, the arm remaining cocked—if I may apply that expression to a spiral spring. If desired, the safety-bolt can now be employed to secure the gun from going off. For my own part, I think that the proper safety-bolt for all guns is a strict determination invariably to regard them as loaded, cocked, and ready to go off, and invariably so to handle them that in the event of an accidental discharge, no serious consequences could result. Still, there is the safety-bolt, if you will have it. There is also an indicator at the side to show if the arm is cocked or not. This then is the breech-action, which, from all those submitted, was eventually selected by the Committee as the one best calculated to meet the requirements of the service. Still the question remained: Is this action superior to the Snider? On this point a careful comparison was made. The Martini is certainly and obviously quicker than the Snider, a superiority which would become still more evident if the Snider were fired with a long small-bore cartridge; it is of course safer than the Snider without a safety-bolt, while it is not less safe than the latest pattern. Both systems appeared to the Committee to be sufficiently strong, although here they saw an advantage in the divided stock of the Martini, as compared with the whole-stocking of the Snider, in which the wood is greatly cut away for the lock. In number and simplicity of parts, the Martini had a considerable advantage—27 against 39. The Martini is estimated to be cheaper to produce than the Snider. Therefore, it was decided to recommend the Martini-breech in preference to the Snider-breech for the new arm.

All that now remained was to effect an alliance between the Henry-barrel and the Martini-breech to give us the arm of the future. This was done; and as the composite arm exhibited no falling off either in accuracy or rapidity, the Henry-Martini rifle was definitely recommended by the Committee in their Report of Feb. 11th, 1869.

As regards accuracy, the following targets have been obtained with the Henry-Martini:—

	Averages of 5 Targets of 20 Shots each, from each Barrel.	The best of the 5 Targets at each range.	Corrected Angle of Elevation.
			° ′ ″
300 yards	·57 feet	·47 feet	0 38 34
500 „	·95 „	·79 „	1 1 26
800 „	1·63 „	1·29 „	2 2 29
1000 „	2·80 „	2·19 „	2 38 26
1200 „	3·46 „	2·28 „	3 55 34

To most of you, these figures will, no doubt, convey a sufficiently correct idea of the performances of the arm. But, for those who are not acquainted with the technicalities of rifle-shooting, a reference to this diagram (Plate xxi) will suffice to make it tolerably clear. Here is the Snider shooting, taken at its best at 500 yards. Here is the shooting of the Henry-Martini at the same range—about 25 per cent. better; and I should observe, that on several subsequent occasions even better targets have been obtained with the new arm.

As regards rapidity, a rate of fire, without aiming, of 20 rounds in 48 seconds—equal to 25 shots a minute—has been obtained, which is higher, I believe, than has been attained with any other gun, excepting guns which have sacrificed simplicity and other necessary military qualities to this one element of rapidity. The merits of the Henry shooting system such as low trajectory, penetration, non-liability to foul, endurance, &c., already established in the separate branch of the enquiry, of course remain in the composite arm; as do also those advantages of simplicity, resistance to injury from damp, sand, continued use, &c., which have been proved to belong to the Martini breech-mechanism. It may here be mentioned that 3,000 rounds have been fired from one action without producing any deterioration or perceptible alteration. The sighting of this rifle is somewhat different from that of the Enfield, the Whitworth construction having been adopted, and the back-sight having been slightly shifted in position—alterations which, it is believed, will enable the firer to take quicker and more accurate aim, especially in bad light, than the service-sights.

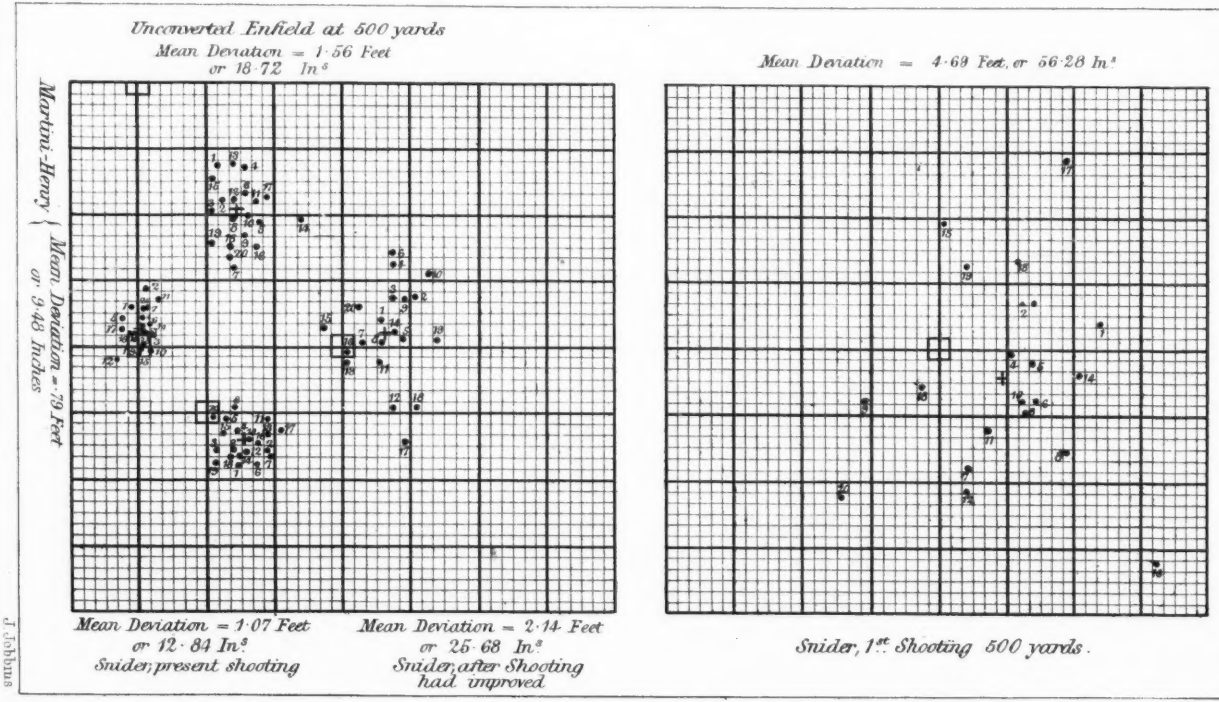
Some trials have been made between the Henry-Martini and Chassepôt rifles, with results largely in favour of the former. (The particulars are given in Appendix C.)

The cartridge, as I have stated, is the Boxer, and therefore we possess in this element all those qualities which have established the success of the service ammunition. The bullet is Mr. Henry's. It is solid, of a maximum diameter equal to that of the bore, ·45″, and is made of lead hardened with tin, in the proportion of 1 of tin to 12 of lead; and the lubrication (pure beeswax) is disposed in a wad behind. There is a paper-cap over the bullet, lightly smeared with beeswax, to prevent leading. The weight is 480 grains. Weight of powder 85 grains.* Total weight of 60 rounds, 6 lbs. 4 oz. 2 drms., as against 6 lbs. 2 oz. 8 drms. for the service Snider-ammunition.

The cost of the new arm is estimated at £2 18*s.* 9*d.*, as against £2 13*s.* 2*d.* for a new Snider (of latest pattern). The weight is 9 lbs. 4½ oz., against 9 lbs. 2 oz.

It was not to be expected, nor was it to be desired, that a new arm should be proposed for adoption without attracting much criticism. It is one of the penalties which success has to pay. I recollect a gentleman whose horse had won a prize at the Horse Show, complaining that he never until that moment knew what a wretched brute he owned.

* Curtis and Harvey's "No. 6" powder was used in the competitive trials; but subsequently a suitable powder has been produced at the Government mills, at Waltham Abbey, with which equally satisfactory, if not superior, results have been obtained.


Unconverted Enfield at 500 yards
Mean Deviation = 1·56 Feet
or 18·72 Ins
Martini-Henry { Mean Deviation = ·79 Feet or 9·48 Inches
Mean Deviation = 4·69 Feet, or 56·28 Ins
Mean Deviation = 1·07 Feet
or 12·84 Ins
Snider; present shooting
Mean Deviation = 2·14 Feet
or 25·68 Ins
Snider; after Shooting had improved
Snider, 1st Shooting 500 yards.

J. Jobbins

It was possessed, so observers pointed out, of every defect which goes to render a horse worthless; it was unsound from head to tail. I confess that having watched with some interest the very satisfactory performances of the Martini-gun for about two years, I have been surprised by the statements which I have met with since it was selected, as to its worthlessness. I read somewhere no less than eight vital objections to the system; and it was not until I had satisfied myself, by a careful re-perusal, that the writer had probably never seen a Martini-rifle, that I felt at ease. Seriously, however, the greater part of the objections which have been urged against the system, are totally without weight. Thus we have been told that the face of the block is necessarily convex, and that it therefore fails to afford to the base of the cartridge the requisite support. To this the simple answer is: It is not convex, as you will see if you examine this arm, but perfectly flat and lying dead true against the face of the cartridge.

Then it has been said that if you happen to pull the trigger before the block is closed, it will fire the cartridge. This objection must be met with a contradiction, the trustworthiness of which I can illustrate by the very simple experiment of snapping a few cartridges (empty of course, but having percussion powder in the caps), and you will see that they do not go off. Then it is said—but this was said by a critic evidently pushed for objections—that the empty case may be ejected into the face of the rear-rank-man. Is it worth while to point out that the force of ejection may be regulated as may be desired, and that there is no reason whatever why the front-rank-man should pepper his rear-rank in this way; and if he does, do you think the latter will be a serious sufferer?

I need hardly go through these alleged objections seriatim. But one must be noticed. Some persons strongly object to a spiral-spring. They say that it is uncertain, and liable to break, and will not efficiently replace the side-lock. If this is true, it is a very substantial objection; but there are *as yet* no grounds for believing it to be true. I cannot even discover upon what evidence it is supposed to rest. The spiral-springs have throughout the competition shown no uncertainty or liability to fail; and the Snider-rifle, which contains three of such springs, has not failed. The French and Prussians use spiral-springs, apparently to their complete satisfaction, for indeed, this appears to be about the only portion of the Chassepôt and needle-guns which it has not been proposed to alter. And a spiral-spring is a well-known mechanical application of power, and would hardly be so largely used in delicate instruments, if it furnished fluctuating and uncertain results. However, the best answer to this and the other criticisms is, that the arm will not be adopted for the service until these objections have been proved not to exist. It is intended to issue some of these rifles to the troops for trial in various parts of the world, and under all circumstances. If the objections exist, and if they cannot be overcome, then the contemplated adoption of the arm will of course be abandoned. If, on the other hand, the rifle gives satisfactory results in the hands of the soldier, its introduction

will be confirmed. And this last is the result which I venture to predict.

Preparations are now being made for the supply of 200 hand-made arms, the whole of which will be ready by August next, and of which some are to be completed before the Wimbledon meeting. The plant at Enfield is also undergoing modification to adapt it to turn out Martini-Henry rifles, at a rate of about 400 per week, not later than the beginning of next year, and perhaps very much sooner. Thus the capability of the manufacturing departments to produce arms and ammunition in large quantities and of uniform quality will also be fully tested.

Before concluding, there are one or two matters incidental to the new arm to which I must briefly refer. There is, first, the question of the bayonet to be used. It is not disputed that the great multiplication in the rate of fire, which is the characteristic result of the adoption of an efficient breech-loader, must largely affect the question of the utility of the bayonet. The occasions have hitherto been rare on which troops have crossed bayonets *en masse*, or in which the bayonet has been actually called into play to repel a cavalry charge. Such occasions must henceforth be rarer still; and it is only in what we may call accidental instances, or in isolated personal contests, that the bayonet is likely henceforward to be used. But you may not deprive the soldier of this weapon altogether, and in determining the length and strength of his rifle you must still bear in mind that it may have to serve as the handle of a pike. These considerations have influenced the Committee in adopting an arm only four inches shorter than the Enfield rifle for general service; and in the substitution for the old bayonet of a weapon of more general utility. Here is the saw-sword bayonet which it is proposed to adopt with the Henry-Martini arm, and of which the general efficiency, whether as a bayonet, as a sword, or as a saw, seems to be sufficiently established by the experiments which have been made with it. Thus, a freshly-killed sheep, dressed in a soldier's great coat, has been thrust through with this weapon, through coat and wool, up to the hilt of the bayonet, smashing bones in its passage. It was then twisted about inside the sheep to test the security of the fastenings and the strength of the barrel. Then a butcher cut up the sheep with the sword, and, finally, sawed through the leg bone of an ox. The bayonet was driven 6 inches through a 1-inch white-pine door, and these two Norway spars of $2\frac{1}{4}$ inches and $3\frac{3}{4}$ inches diameter, were sawn through in 16 seconds and 1 minute respectively. Finally, this exceedingly tough piece of dry elm, 3 inches square, was sawn through, although in this instance of course the process was slow. So that the soldier will have at once a bayonet, a *couteau de chasse*, and a means of sawing firewood, and cutting up his rations, and be, therefore, more perfectly equipped than when armed only with an ordinary bayonet. These saw-sword bayonets are already used by the Irish constabulary.

One other point to be noticed in connection with the arm of the future is, the proposed trial of gun-cotton. So important a subject can hardly be worthily introduced at the end of a lecture; and I must assume that you are acquainted with the vast progress which, thanks

mainly to Mr. Abel, has lately been made in this subject. I must assume that you are acquainted with the fact, which seems to have been most conclusively established, that gun-cotton, as now made, will be no more liable to spontaneous explosion than gunpowder; that it will not explode under about 300° Fahrenheit, which is practically as purely artificial a temperature, as that at which gunpowder explodes; and that by means of Mr. Abel's pulping process—the gun-cotton being reduced to pulp, like the pulp of a paper-mill, and afterwards compressed into charges of the required form and density, a combustion of a perfectly uniform character can be established; while by the dilution of this pulp, with some plain cotton pulp, or with a less explosive gun-cotton pulp, or by saturating the fibre with some inert varnish or deadening material, such as india-rubber dissolved in benzole, or similar bodies introduced into the fibre of the gun-cotton, the violence of the explosion may be considerably modified; and the varnish serves at the same time to render the material waterproof. What is now needed is, carefully and accurately to adjust these various conditions; to determine the weight of charge, its density, the amount and precise nature of varnish or of less combustible gun-cotton to be introduced; to determine in fact, by trial and error, the most efficient combination of the materials now lying ready to hand. This clearly is a matter for experimental inquiry, and you will, I am sure, be glad to hear that the subject has already been referred to a Government Committee. Assuredly, it is worth while to endeavour once for all, to determine the suitability of a material which would enable us to fight our battles without smoke; to use our rifles without even faintly fouling them; to reduce the weight and bulk of our ammunition; to be free from all liability to permanent injury by damp (as damp gun-cotton can be restored by simply drying it); and which would sensibly diminish recoil.

There is still one subject without some reference to which my remarks would be strangely incomplete. I have said that the revival of breech-loaders came exactly at the proper time, and as a sort of natural step or consequence in the development of fire-arms. If we trace in outline the history of weapons, we may observe this: First, there was the time when man attacked his enemy and his prey with the weapons with which nature had provided him. Then, probably immediately, came the epoch of auxiliary weapons—the fist weighted with a stone, the hand grasping a rude stick or club. Gradually these weapons assumed definite forms and a recognized importance. Their construction and use became methodized, as it were, and gave us fashioned side-arms of stone or flint, of wood and bronze, of iron and steel. The next development consisted in the introduction of missile weapons—the javelin, the assegai, and others to be thrown by hand, with feeble projectile weapons, such as the blow-pipe for projecting poisoned arrows, the bow, the cross-bow, and the sling. These weapons mark the connecting link between hand and fire-arms; and at this point, it may be noticed, body armour generally disappeared. Passing yet forward, we strike the track which leads directly down to our own age. The range of the blow-pipe and the sling and bow was

so small, and their accuracy so imperfect, that the next improvements naturally took these directions. It is to the introduction of fire-arms that we trace the enormous development in both the range and accuracy of offensive weapons. And in these directions for many years men laboured; and the labours of Thierry, Delvigne, Thouvenin, Norton, and Minié at last fructified in the almost universal adoption for military purposes of the elongated rifle bullet, of great range and accuracy; and when the tide had once set in, it flowed strongly in this direction, and one inventor after another contributed his ingenuity to the perfecting of "arms of precision."

But there is a point beyond which nothing of practical utility remains to be accomplished in the matter of range and accuracy. The line has been drawn in England considerably in advance of the standard adopted on the continent, but wherever that line be drawn, there is the point beyond which it is practically useless to travel, and when this point is reached, men turn instinctively to the improvement of small arms in another direction. What then is the direction in which they will strive? Plainly, when the requirements of range and accuracy have been fully satisfied, the multiplication of the rate of fire, and the facilitation of its delivery, become the next objects to be accomplished. And thus we reach, as I have said, by a process of natural development, the "breech-loading" epoch; and if you should ask me to point you to the spring tides of these two last epochs, I would instance the two Paris Exhibitions—that of 1855 for the most remarkable novelties in "arms of precision;" and that of 1867 for the most remarkable expression of the "breech-loading" activity of the age. And then—looking forward—what is the next epoch; in what direction have we now to strive? If the next International Exhibition should be one of war, and not of peace, as is not impossible, what is likely to be its most distinguished military novelty?

Gentlemen, I think we can be in no doubt as to our answer. What we have now to do is to seek an efficient and ready means of defence for our soldiers against these terrible "arms of precision," which can pour forth such an amazing stream of fire, consuming all it touches. Most earnestly do I hope that this very important subject will not be neglected. We cannot, it is true, go back to "body armour," for no armour which a man could carry would resist a bullet capable of piercing $\frac{1}{4}$-inch iron. But we may by the establishment of a system of field entrenchment do much to afford cover and concealment to our men, and by an improved method of skirmishing do much to diminish their exposure. I confess I view with uneasiness the absence among us of any vigorous action in this matter—of any decided attempts to instruct our troops in the art of swiftly covering themselves, or to supply them with the means of doing so.* For, in my opinion, the nation which shall first grasp the full value of the necessity of the spade as an implement of warlike application, and which shall first

* Since this lecture was delivered, the author has learned that a Committee has been appointed to consider this subject, together with points connected with drill and skirmishing.

reduce its use to an efficient system, will gain as great an advantage over its opponents, in degree if not in kind, as was conferred by the first possession of breech-loaders.

APPENDIX A.

PENETRATION TRIALS OF HENRY ·45 INCH, EXPERIMENTAL ·5 INCH, AND SERVICE ·577 INCH BORES.

When fired through ½ inch elm planks, placed 1 inch apart,

The Henry ·45″ hardened lead bullet made an average penetration of .. .. 14½ planks
The ·5″ hollow lead bullet made an average penetration of 8½ „
The ·577″ ditto „ „ 8½ „

When fired through 3 inch balks of dry fir timber, placed close together, at 50 yards distance, the ·5″ and ·577″ Snider bullets were stopped by the second balks. The Henry ·45″ bullets penetrated three balks easily.

At 100 yards distance, the Henry bullet also penetrated three balks easily, and a fourth balk of green fir having been added, making in all 12 inches of wood, two out of three bullets penetrated. Thus, whilst two balks of timber at 100 yards distance were proof against bullets from the ·5″ and ·577″ bores, four balks of timber at 100 yards were not proof against the Henry bullet from the ·45″ bore.

When fired against iron plates, the following results were obtained:—

PLATE ·261″ THICK.			PLATE ·125″ THICK.
·577″ bore penetrated at	75, not at 100 yards.	}	Failed at 300 yards.
·5″ bore „	100, „ 150 „		
Henry ·45″ bore „	200, „ 300 „		Penetrated at 500 yards.

When fired at a rope mantlet (four thicknesses of 3-inch rope),

The ·577″ failed to penetrate at 50 yards distance.
The ·5″ penetrated at 50 but failed at 100 yards.
Henry ·45″ „ 350 „ 400 „

When fired at an ordinary gabion filled with earth from a clay soil,

The ·577″ and ·5″ failed to penetrate.
The Henry ·45″ penetrated at 10 and 25 yards, but failed at longer distances.
The Jones (iron band) gabion was proof against all.

When fired at a sap roller,

The ·577″ and ·5″ failed to penetrate.
The Henry ·45″ penetrated at 10 yards and at 25 yards, but failed at the longer distances.

When fired at a sand-bag containing one bushel of sand,

The ·577″ and ·5″ failed to penetrate.
The Henry ·45″ penetrated at 10 yards and at 100 yards.

The above is extracted from Report of Breech-loader Committee (1869), p. xviii.

In addition to the above, other penetrations have been made since the Report of the Committee was rendered, a detailed account of which are given in the *Proceedings Royal Artillery Institution.*—"Short Notes on Professional Subjects," 1869, pp. 80 to 83.

The conclusions drawn by Captain Noble from these experiments are as follows:—

(1) Steel plates offer a much greater resistance than those of wrought-iron.

(2) A steel plate of No. 5, Birmingham gauge, 0·217 inch in thickness, is proof at 10 yards against any small arm bullet likely to be used for some time to come.

(3) A wrought-iron plate of 0·312 inch thickness is not proof against the Henry bullet at 25 yards.

(4) A Jones's gabion filled with stiff earth is proof against any small arm bullet at 10 yards.

(5) A slight breastwork of filled sand-bags or loose earth is proof against all small arms.

(6) The rope mantelet used, gave unsatisfactory results.

(7) Two 3-inch planks of green oak are proof against any small arm bullet at 50 yards.

(8) The Henry bullet will pass through 12 inches of fir planks at 100 yards.

APPENDIX B.

RETURN of Boxer Cartridges, without Safety-Anvil (first pattern), which have exploded from accident or otherwise.

Date.	Place.	Cause of Explosion.
1866.		
October 1	Rl. Laboratory	A cartridge fell on iron standard and fired
„ 2	Do.	Upon placing cartridge in box to clean the bullet, it fired
„ 9	Do.	A cartridge fell on iron standard, and fired
„ „	Montreal	In the operation of unloading box from ship
1867.		
March 2.....	Rl. Laboratory	In the operation of heading quarter-barrel, a cartridge fired
August 14.....	Do.	Ditto ditto
October 1	Do.	Cap fired while chamber-gauging empty cases
1868.		
January 27....	Do.	Cap fired by fall of empty cartridge on to the floor
February 7....	Do.	Transferring Boxer ball in boxes returned from Canada, cartridge fired
January 20....	Do.	Ditto ditto
February 17...	Do.	In ammunition returned from Canada one cartridge had fired
March 18	Do.	In operation of heading up barrel, containing blank converted from ball of Pattern I.
„ 4	Do.	While chamber-gauging blank cartridges, one fired
„ 18	Do.	In operation of heading up a barrel containing blank converted from Ball I.
„ 28	Do.	Blank returned from Canada for examination, in process of packing into bundles
April 1.....	Do.	Heading up barrel of blank, converted from No. I.
„ 3.....	Do.	Packing a bundle of ditto
August 27.....	Do.	Securing lid of box, containing Ball I. returned from Canada for conversion.

Some other instances of the same sort have occurred, but not having been accurately recorded, they are not included in this return.

APPENDIX C.

TRIAL OF IMPROVED CHASSEPÔT, FIRED IN COMPARISON WITH THE MARTINI-HENRY ARM FOR ACCURACY AT 500 YARDS RANGE :—

An unofficial trial of the Chassepôt, in comparison with the Martini-Henry rifle, has recently been made at the Proof Butt, Woolwich, by the Sub-Committee on Small Arms, with very satisfactory results.

Captain Simon, of the French Artillery, submitted for trial there

improved Chassepôts, and they were fired in comparison with the Martini-Henry arm for accuracy at 500 yards range.

The results of the shooting were as follows: –

Arm.	By whom fired.	Mean deviation of 20 shots.
		Feet.
Martini-Henry, No. 3..	Serjeant Bott, R.M., kneeling position....	1·03
Chassepôt, No. 1.....	Captain Simon, from shoulder rest	2·78
Martini-Henry, No. 3..	„ „ „	0·97
Chassepôt, No. 1.....	Serjeant Bott, R.M., kneeling position....	3·02
Martini-Henry, No. 1..	Edward Ross, Esq., sitting position	0·96
Chassepôt, No. 2.....	Captain Simon, from shoulder rest	2·78
Martini-Henry, No. 1..	„ „ „	1·62
Chassepôt, No. 2.....	Captain Mackinnon, sitting position.....	2·38

Thus the accuracy of the Martini-Henry arm far excelled the Chassepôt.

Heights of trajectories of the two arms at 500 yards. Chassepôt 10 feet at its highest point. Martini-Henry 8 feet 2 inches.

In simplicity of manipulation the latter arm is also superior.

20 rounds were fired for rapidity, with the following result:—

Chassepôt..... 1 minute 42 seconds.
Martini-Henry..... 0 „ 48 „

The manipulation of the Chassepôt was found very fatiguing. In simplicity and strength of construction, the advantage appears to be with the Martini-Henry arm.

Captain Simon informed the Sub-Committee that the French soldier carries two spare spiral-springs, two needles, and one india-rubber washer, to replace any breakages or injury to these parts.

There were no mis-fires with the Chassepôt out of the few rounds fired by the Sub-Committee, but after 10 rounds it became difficult to push home the cartridge, owing to the clogging of the chamber, the cartridges had to be forced in by blows, sometimes frequently repeated. In the event of a mis-fire, there is no way of withdrawing the cartridge except by using the ramrod.

The ammunition of the Martini-Henry arm is slightly more bulky than that of the Chassepôt.

The weight of the 90 rounds is:—

	lbs.	oz.
Chassepôt	6	9
Martini-Henry	9	5

The bullet of the latter, however, weighing 480 grains, against 380, the weight of the Chassepôt bullet. The cost of the cartridge is believed to be about equal.

The only advantage in favour of the Chassepôt is in the lightness of its ammunition. This is counterbalanced by the following points, which are in favour of the Martini-Henry arm:—

Increased strength and safety of ammunition.
Greater accuracy.
Longer range.
Flatter trajectory.
Higher penetrative power.
Greater safety, strength and simplicity of construction.
Increased rapidity of fire.

(From *Proceedings R. A. Institution.* "Short Notes on Professional Subjects, 1869," pp. 79, 80.)

DESCRIPTION OF PLATE XX.

a. Barrel
b. Body
c. Block
d. Block axis-pin
e. Striker
f. Main-spring
g. Stop-nut
h. Extractor
i. Extractor axis-pin
j. Rod and fore-end holder
k. Rod and fore-end holder screw
l. Ramrod
m. Stock fore-end
n. Tumbler
o. Lever
p. Lever and tumbler axis-pin
q. Trigger-plate and guard
r. Trigger
s. Tumbler-rest
t. Trigger and rest axis-pin
u. Trigger and rest-spring
v. Stock-butt
w. Stock-bolt
z. Lever catch-block spring and pin
A. Locking-bolt
B. Thumb-piece

LECTURE.

Friday, May 13th, 1869.

REAR-ADMIRAL SIR FREDERICK W. E. NICOLSON, Bart., C.B., Vice-President, in the Chair.

THE USE OF THE COLLIMATOR FOR LAYING GUNS FOR NIGHT-FIRING.

By Lieut.-Colonel D. DAVIDSON, late Bombay Army.

IN regard to my plan for laying guns and mortars which I am about to explain, I may say in the first place, historically, that it was suggested during the siege of Sebastopol to meet a difficulty felt by the attacking party. The Russians were in the habit during the night of repairing the damage done to their works by our batteries during the day, replacing the silenced guns by fresh ones, and so presenting insuperable difficulties to an attack. This led me to offer, by the help of the very simple apparatus now to be described, so to register the aim taken at the object with the ordinary sights as to be able to restore it without again sighting the object, and thus to maintain an accurate and effectual fire throughout the darkest night. Of course the practice could by the same appliance be continued during the day with the embrasures closed, and the gunners protected from the fire of the enemy, and all this by means of a much more rapid and easy mode of laying than that with the ordinary sights.

The system was subjected to careful trial at Woolwich by the Select Committee, and approved of, and between 30 and 40 sets of the instruments were ordered out to the Crimea; but owing to unfortunate obstructions which I met with at an earlier stage, and over which I had no control, Sebastopol was taken before the instruments had left this country. They were then distributed for practice among some of our Artillery stations at home and abroad. But the invention

Fig. 1.

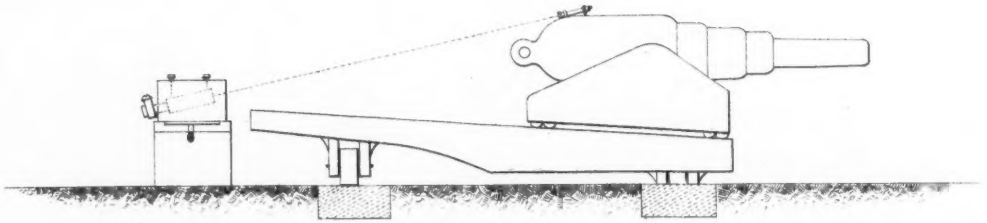


Fig. 8.

Fig. 2.

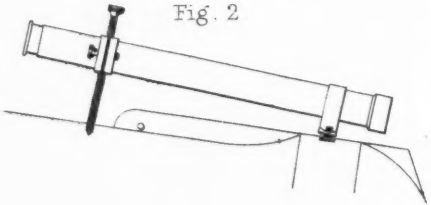


Fig. 4.

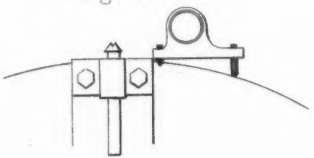


Fig. 5.

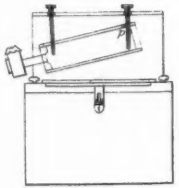


Fig. 6.

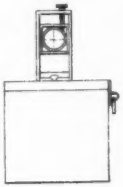


Fig. 7.

Fig. 7.

Fig. 8.

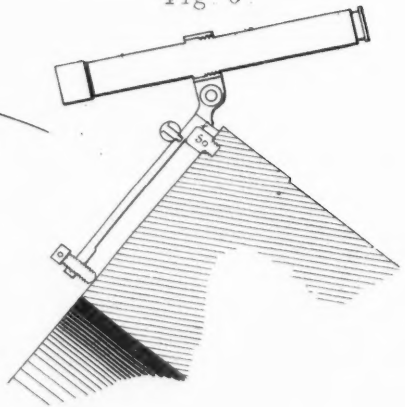


Fig 9.

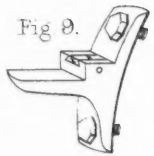


Fig. 10

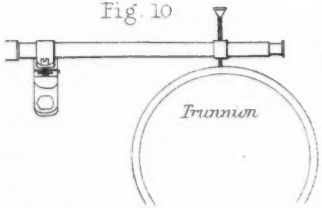


Fig 11

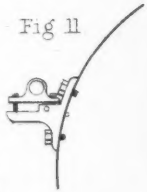
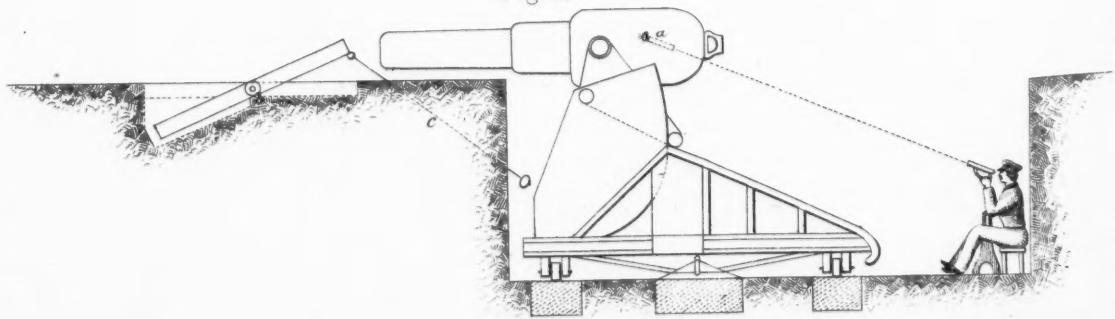


Fig. 12.



J. Jobbins.

Pl XXII.

appears to have been allowed to fall into a happy state of slumber, from which it is my present object to awaken it, especially with a view to its application to the Moncrieff system, to which I shall afterwards refer.

The apparatus consists of a telescope temporarily applied to the piece, and looking backwards or behind it, where, at a short distance, just clear of the recoil, is fixed a collimating telescope, whose cross lines are to be bisected by those of the first telescope. (See Fig. 1, Plate xxii.) The accuracy of this plan is vouched for by its frequent use in astronomical observatories. The practical arrangements for securing its sufficiency and fitness for the present purpose are now to be described.

The apparatus consists of two parts—the telescope and the collimator. The telescope is achromatic, of an inch aperture, and about eleven inches long (see Fig. 2). At each end of its tube is fixed a collar, that at the eye-end (Fig. 3) has an elevating screw pointed at the lower end, and capable of being clamped when the telescope has been adjusted to the collimator. The collar at the object end of the telescope (Fig. 4) has two screw feet, the shorter of which is pointed. On the fourth lens from the eye end of the telescope a cross is cut thus —

To make this telescope available for any gun, the gun should be laid "point-blank" at any conspicuous object. The telescope is then placed upon the gun, with the front collar resting on the "base ring," to the right, and just clear of the "vent field," and ordinary sight (see Figs. 2 and 4). The eye-end of the telescope is now moved, and the elevating-screw turned, till the object at which the gun is pointed is cut by the cross, as seen diminished by looking in at the object or reverse end of the telescope. A mark is then made on the gun where the point of the elevating screw touches it; and at that point a small hole is punched in the surface of the gun, sufficient to receive the sharp point of the screw. The point of the screw is now placed in this hole, and the telescope adjusted as before, so that the cross intersects the object, and the position occupied by the pointed foot at the object-end being carefully marked, a longitudinal cut in the direction of the axis of the gun is made with a cold chisel, deep enough to receive the pointed foot. It is made longitudinal here, because as I elevate or depress this screw, I increase or shorten the distance between the points, so that two round holes would not suit. By this arrangement the axis of the telescope is placed parallel to the axis of the gun, or sufficiently so for practical purposes; and if removed and replaced, the axis of the telescope maintains a constant relative position to the axis of the gun. For example, if I were to intersect any minute object with the telescope, when so applied to the gun, and then take it off and put it on again, I should find the object intersected just the same as if the telescope had never been moved.

The collimator consists of an achromatic lens of about 3½ inches aperture, and about 15 inches focal length, mounted in a square wooden tube. (In Figs. 1, 5, and 6, it is shown placed on the top of its packing box ready for use.) At the other end of the tube is a disc of glass, 1¼ inch in diameter, secured in a brass tube, and having a cross cut on it, thus :— To illuminate this cross, a tube with a diagonal reflector is fixed to it for day-use, and a small lantern, having a piece of ground glass to disperse the light, is substituted for the reflector for use during the night. This telescope or collimator is suspended in a wooden case (open at both ends) by means of two long screws, the milled heads of which appear above the top of the case. By turning these milled heads the collimator is raised or lowered, and placed at any required angle. A pivot (*p*) attached to the tube enters a vertical channel cut in the inner sides of the case, and two brass springs fixed to one side of the tube press it against the opposite side of the case, and keep the tube steady. When in use, the collimator is placed on the top of its packing box, to which it is secured by a thumb screw at each end, which are so arranged as to admit of the collimator being moved to either side on the horizontal plane, or angularly in that plane, and there clamped. Thus the collimating telescope has motion in every required direction.

To Use the Telescope and Collimator.

The gun having been laid during the day by means of the ordinary sights on the object to be struck, the collimator, fixed to its packing-box, is placed on the ground in rear of the gun and clear of the recoil. (See Fig. 1). The telescope is then applied to the gun in the manner already described, and the elevating-screw is turned till the cross in the telescope is level with the centre of the object-glass of the collimator. The collimator is then moved, packing-box and all, till the object-glass is nearly in the cross of the telescope, and a minute lateral movement is then given to the collimator on the packing-box, by tapping it with a hammer. When the object-glass of the collimator is thus brought into the centre of the cross, the farther end of the collimator is moved by tapping to either side till the perpendicular line of its cross appears in view, and gradually reaches the centre of the field, thus :—

The farther end is then elevated or depressed as the case may require, by means of the screw, till the horizontal line appears in the centre, thus :— The collimator and telescope are then minutely

moved till the crosses in each intersect thus:— In this position the collimator is secured firmly to the packing-box by the clamping screws. The elevating screw of the telescope is also clamped, and the telescope removed.

The collimator and telescope having been in this manner adjusted to the aim of the gun, the gun may be fired, loaded, and run up. The telescope is then applied as before, and the gun is now moved till the cross in the telescope bisects the cross in the collimator, when the gun will have been restored to the position in which it stood before the shot was fired, or else into one exactly parallel to it in every respect, which for all practical purposes is the same thing.

The collimator sends out a column of parallel rays, each giving an image of the cross in the focus, any one of which may be used for registering the aim of the gun. If I take a central ray, then I get my intersection in the centre of the field of the collimator. But if the gun has been moved several inches to one side, I find, perhaps, that the ray I meet in the collimator is on one side of the field thus :—

But still, I can make my intersection there, and I get the gun then laid perfectly parallel to its first position in the horizontal and vertical plane; so that, if there is an error, it is a parallel error just amounting to the extent to which the gun has been moved—perhaps an inch or an inch and a half—and it will strike the object an inch or an inch and a half on one side, supposing the gun to shoot perfectly true.

If long intervals occur between the rounds, the gun should be restored to aim immediately after firing, so that in the event of an accident or a shot disturbing the position of the collimator, it can be re-adjusted to the gun, or, if destroyed, it can be replaced by another.

In elevating the eye-end of the telescope to make it point down towards the collimator, it is evident that the axis of the telescope is no longer parallel to the axis of the gun in the horizontal plane. This, in the event of the platform losing its level position, would involve an error similar to that which occurs when using the tangent scale under the same circumstances. But this error is of little consequence except when the gun is fired with high elevations. In such cases, the error can be entirely obviated without levelling the platform, by merely unscrewing the elevating-screw of the telescope till its axis is parallel, or nearly so, to the axis of the piece, and then raising the collimator to meet the telescope, which can be readily done by means of a pillar of stones and mud, or by a gabion cut to the requisite height and filled with earth.

To give steadiness to the collimator it is well to put two or three shot into the packing-box.

Before describing the application of the instrument to mortars, I

may as well show practically, by means of the model gun upon the table, how the aim is registered and restored.

Suppose this gun to be laid by the ordinary sights upon the object. I apply the telescope to a hole and cut in the gun already described, and an assistant moves the collimator till the intersection of the crosses is made. The aim is now registered and the collimator clamped. The gun is now fired and completely displaced, as I now displace the model. I run it up as nearly as I can guess to the position it occupied before it was fired, and, as you see, apply the telescope and look through it into the collimator. I find the crosses no longer intersect, so I move the gun instead of the collimator till the intersection is made. It occupies, as you see, only a few seconds, and now the gun is ready to fire. If fired, and the gun perfectly accurate in its performance, the shot will hit in exactly the same place as the first, because the gun is mathematically restored either to the same position or to one exactly parallel in every respect to that in which it originally was laid. I need not say that the simplicity of laying is very great, because you have these two crosses, minute in themselves, but magnified as large as the cross-bars of the window, to divide each other. You might pick up a boy in the street and teach him in five minutes to lay the gun as well as the most skilled gunner you can produce.

The Application of the Instrument to Mortars.

In the case of mortars, a small spirit-level is attached to the telescope, which is mounted, and applied to the mortar in the following manner:—

The telescope is attached to the upper part of an arc of gun metal by a strong joint which can be clamped at any angle (see Figs. 7 and 8). This arc has a flange (*f*) along its outer edge, which receives in its angle two cylindrical-headed studs half an inch in diameter and half an inch high (*s s* and *s*, Figs. 7 and 8). These studs are $3\frac{1}{2}$ inches apart, and are screwed into the muzzle or face of the mortar, half an inch from its upper edge. The screw-foot at the lower extremity of the arc adjusts the face of the arc into a position parallel to the muzzle of the mortar, and when the arc is placed so as to hang upon the studs, it circles round this screw-foot as a centre, till the bubble is in the centre of the level.

The collimator used with mortars is of the same construction as that already described for guns, but is not quite so large.

To use the Telescope and Collimator with Mortars.

Lay the mortar in the usual manner. Apply the telescope to the studs, and move it gently on them till it is level. Elevate or depress the telescope till its cross is on a level with the centre of the object-glass of the collimator which is placed on its box in front of the mortar under shelter of the epaulment. Adjust the collimator in the

manner already described, so that its cross shall bisect the cross of the telescope. The collimator is then clamped, and remains a fixture while the firing continues, and the telescope is removed.

The mortar having been fired, it is loaded and run up as nearly as possible (as shown by a chalk mark on the platform) to its original position. The telescope is replaced on the studs and moved till level, and the mortar is then moved forwards, backwards, or to one side, till the intersection of the crosses is made, when the aim will be exactly restored.

On an emergency, the studs in the muzzle of the mortar may be dispensed with, and the flange of the arc can be placed on the upper edge of the muzzle.

I should like to explain in a few words one great advantage this method of laying a mortar has over the present system. To lay a mortar under the present system, two points are placed in front of the mortar, carefully aligned in the direction of the object to be struck. Having found the exact centre of the mortar by means of a spirit-level, and drawn a chalk mark in the line of its axis, an attempt is made, by means of a plumb-line, to make the axis of the mortar coincide with the two points in the vertical plane. Now to restore the mortar truly, it must be brought back after every discharge to this identical line, and this is no easy matter, as in traversing right and left, there is constant liability to pass beyond the line. Whereas by the use of the collimator, we have, instead of one line on which to bring the axis of the mortar, a whole column of lines or rays, in any one of which, the mortar may be laid in a parallel position, while the elevation of the piece is restored with mathematical exactness. This method of laying a mortar is also exceedingly rapid.

Telescopic Sight for Cannon.

The telescope used in conjunction with the collimator is so constructed that it can be made available for giving the aim, by looking through it directly at the object to be struck. In the upper side of the shoulder of the left trunnion of the gun a hole is made to receive the point of the elevating screw of the telescope. In front of the trunnion, at the proper distance, a bracket (Fig. 9) is fixed for the feet of the front collar of the telescope to rest on. This bracket is made of gun-metal, and is fixed to the gun by screws, in the same manner as the fore-sight (see Figs. 10 and 11). In the upper step of the bracket there is a dovetail slide (*z* Fig. 9), which can be fixed by a pinching-screw when the telescope is adjusted to the axis of the gun. In the upper surface of this slide a longitudinal channel, similar to that on the base-ring, is formed to receive the shorter foot of the front collar, while the longer foot rests on the lower step of the bracket, and gives steadiness to the telescope. The distance between the point of the elevating-screw and that of the shorter foot of the front collar is so regulated, with reference to the thread of the elevating-screw, that one turn of that screw is equal to one quarter of a degree of elevation.

One side of the elevating-screw being flattened, the degrees are marked off on it, and one or more turns of the screw give the quarters.

The adjustment of the telescope to the gun is made by bringing the gun point-blank on a distant object, by means of the ordinary sight. The elevating-screw of the telescope being fixed at the zero of its scale, its point is inserted in the hole of the stud in the trunnion, and the shorter foot of the front collar is placed in the channel of the dovetail slide, while the longer foot rests on the lower step of the bracket. The object at which the gun is pointed, is then viewed through the telescope, and the screw feet in the front collar are turned till the intersection of the lines in the telescope is exactly the height of the object. The horizontal adjustment is readily effected by moving the dovetailed slide (*z*), which is then securely fixed by the pinching-screw.

Advantages of the Telescope and Collimator.

The most obvious advantage of this apparatus is that it affords the means of continuing the fire of guns and mortars throughout the night with as much precision as can be attained during the day; thus preventing the repair of works and the replacement of guns in the night. Indeed, by means of the telescope and collimator, the fire of batteries might be maintained solely at night, or during the day under cover of smoke and fog, when the enemy, unless similarly provided, could not return an equally effective fire.

As the use of the instrument admits of the embrasures being closed, except at the moment of firing, the men who work and point the gun are not exposed to the direct fire of the enemy.

The laying of a gun or mortar by the collimator is rapid, easy, and mathematically accurate. The crosses being in the same plane of vision, and greatly magnified, their intersection is much more obvious and distinct than the alignement of the ordinary sights with the object; and can be effected as well by a short-sighted person as by one whose vision is perfect.

In making experiments to test the accuracy of different kinds of ordnance and variously shaped projectiles, an important source of error, that of pointing, may be got rid of, by using the telescope and collimator to lay the piece.

The arrangements I have now described had reference to a particular emergency, and during the eleven years which have elapsed, great improvements have been made, not only in guns, but in the methods of laying them. To one of these, the Moncrieff system—the advantages of which have been fully established—I believe the use of the telescope and collimator would form a suitable adjunct, more especially when that system is applied to guns in position in field or siege operations. Captain Moncrieff has made provision for doing the same thing in permanent batteries by means of a trunnion-pointer and graduated-racer. When that system is employed in siege operations, field operations with guns of position, or in temporary batteries with

any kind of guns, the collimator might prove a useful adjunct, as it would give accurate results in all conditions.

As regards the methods of making this application of the collimator, that would be a matter for future arrangement; but I shall briefly indicate a plan that seems suited to the purpose.

Fig. 12 is a sketch of the Moncrieff gun, on which at *a* the position of the collimator is marked with dotted lines. In this case, as suggested by Captain Moncrieff, the collimator is fixed permanently to the gun, instead of the telescope being temporarily applied to it. The collimator has its axis parallel to the axis of the gun in the vertical plane, and need not be so large as in the other case. It has its cross illuminated by a small lantern. The telescope may either be attached to a heavy movable stand placed on the opposite side of the pit, or it may be clamped to any convenient part of a circular rod running round the edge of the pit. In either case the telescope would have a means of rapid and minute adjustment in the horizontal and vertical plane by something like a slide rest arrangement, so that by intersecting with its cross lines the cross in the collimator, it could register in a moment the laying of the gun. When the gun is fired, reloaded, and brought up to the firing position, it is probable, from its construction, that, on looking through the telescope into the collimator, it would be found that very little adjustment was required, and the intersection of the two crosses would be very rapidly made, under the direction of the observer at the telescope, by the men working the gun.

As at short ranges in siege operations, the muzzle of the Moncrieff gun would be exposed to the fire of the enemy at the time of laying, it is important this should be made as rapid as possible; hence the advantage of the collimator. Further, as the gun can be relaid by the collimator without sighting the object, the muzzle might be protected during the time of laying by the iron shield balanced at *b*, Fig. 12, and worked by a rod, *c*, from the inside of the pit. By such an arrangement as this, I can conceive the Moncrieff gun to be made perfectly impregnable.

The CHAIRMAN: If any gentleman wishes to make any observations we shall be happy to hear him.

Major-General LEFROY, R.A., F.R.S.: I had the pleasure of having some official intercourse with Colonel (then Major) Davidson about fifteen years ago, when this subject was first brought forward, and I then formed an extremely favourable impression of it, which I retain. The application of the principle of the collimator is exceedingly happy; it is a familiar thing to astronomers, in connection with fixed instruments, as a convenient way of adjusting two axes of any kind, whatever their distance from one another. The collimator of Colonel Davidson is actually in the service, although probably few people are aware of it. It does not often happen in any description of warfare that we are firing at fixed objects. It may be said to be confined to siege operations and to the defence of fortified places. For some years past our minds have been principally directed to coast defences of all kinds, where we have to fire at moveable objects, and where, consequently, an arrangement of this kind is inapplicable. But if such a siege as that of Sebastopol were to occur again, I have no doubt that this instrument would be employed. It was introduced into the service in 1863, and stands among our special provisions for certain occasions. When Colonel

Davidson brought it forward, he fell on evil days, on times when our minds had not become accustomed to the refinements in artillery practice, necessitating that precision of laying guns which we now aim at. Although the Government actually sent out ten of these instruments to different stations, I never could learn that they were used; at least, I only knew of one instance in which they were used. The general reception they met with was, that people understood them, but would not be bothered with them, and went on aiming in the old way. There is always a tendency to that kind of preference for rough and ready measures; we find inventions of this description disregarded in the excitement of action. But if occasions of service should again arise, the Officers of the Royal Artillery are now perfectly well prepared to appreciate the advantages of the collimator; and if I had anything to do with such matters, it would be my desire to see it used in all suitable cases. I am satisfied it will give extreme accuracy in laying guns, combined with those conditions of security which the use of arms of precision now renders so necessary.

Captain MONCRIEFF: I should like to make one or two remarks about this instrument, as I have been acquainted with it for some time as applied by Colonel Davidson. Whatever its value may be as used for guns, there is no doubt that in mortar practice it would be of very great importance. We all know that the present method of laying mortars is a very rude and troublesome one. I am sure that artillerymen would gladly avail themselves of this instrument for sustained fire if they were acquainted with it. The adjustment is rapid, and the aim extremely correct. A mortar battery should be considerably below the crest of the parapet, and out of sight, involving the necessity for taking aim by means of pins, lines, &c., which is one of the most awkward operations as now applied, which I know of. I am therefore inclined to think that the Artillery would gratefully receive the collimator when they became acquainted with its advantages.

The CHAIRMAN: If no other gentleman has any observations to make, I am sure we shall all be happy to return our thanks to Colonel Davidson for the clear manner in which he has brought this subject before us. If it had no other effect than to draw forth the few remarks which General Lefroy has made, it would have answered some good purpose. I am sorry to say that for the Navy the collimator is not applicable, but for firing at fixed objects, I have no doubt it might be brought very much into use, as General Lefroy has remarked.

Evening Meeting.

Monday, May 31st, 1869.

MAJOR-GENERAL F. W. HAMILTON, C.B., Vice-President, in the Chair.

NAMES OF MEMBERS who joined the Institution between the 17th and 31st May, 1869.

ANNUAL.

Walker, W. O., Capt. 7th Royal Lanc. Mil. 1*l.*
Campbell, W., Lieut.-Col. 100th Regt. 1*l.*
Liddell, R. S., Capt. 10th Hussars. 1*l.*
Cope, Richard, Capt. 7th Royal Lanc. Mil. 1*l.*
Westaway, Nathl. Lieut. R.E. 1*l.*
Doncaster, J. B., Lieut. 73rd Regt. 1*l.*
Warren, T. M., Capt. 73rd Regt. 1*l.*
Preston, W. H., Lieut. 73rd Regt. 1*l.*
Mayne, J. T. B., Capt. 73rd Regt. 1*l.*
St. John, E. B., Capt. 73rd Regt. 1*l.*
Boddam, J. W., Lieut. 73rd Regt. 1*l.*
Young, Richard R., Ens. 73rd Regt. 1*l.*
Thomson, W., Paym. 102nd Roy. Mad. Fusilrs. 1*l.*
Williams, J. W. C., Col. Roy. Mar. Art. 1*l.*
Sandeman, D. G., Capt. 1st West Norfolk Mil. 1*l.*
Furse, P. G. F., Esq., Dep. Asst. Com. General.
Baring, E., Lieut. R.A. 1*l.*
Maurice, F., Lieut. R.A. 1*l.*
Carmichael, L. M., Lieut. 5th Royal Irish Lancers, 1*l.*
Colville, Charles, Lieut. 54th Regt. 1*l.*

THE DESTRUCTION OF WRECKS BY EXPLOSIVE COMPOUNDS.

By Lieutenant HERBERT JEKYLL, R.E.

THE application of explosive compounds to the removal of wrecks and other submarine obstructions, has for some time past attracted considerable attention. Channels used for the purposes of navigation have been, and are constantly obstructed by the accidental foundering of vessels, due to a variety of causes, and it becomes imperatively necessary, in the interest of commerce, that such obstructions should be removed. Where practicable it is, of course, expedient to raise a sunken ship entire, but this is frequently rendered impossible by the nature of the cargo, the silting action of sand, peculiar circumstances of position, or other special reasons, which it is unnecessary to enumerate.

After the failure of all other means, recourse can be had to the force of explosives to effect removal, and there are many instances on record of such demolitions.

I propose to give a short account of some of the principal recorded examples of destructions of wrecks, and to point out the advances which have been made in the art of submarine-mining, since operations of this description were first undertaken.

As far as I am aware, the earliest instance of the application of gunpowder to the destruction of wrecks was in 1831, when a vessel of 350 tons burden, named the "Arethusa," sunk in the harbour of Barbadoes, was blown up by a party of the Royal Sappers and Miners, under Major Reid, R.E. It appears that at low water, this ship was nearly dry, and that in consequence charges were lodged against her without difficulty. I have been unable to find any record of the details of the operations, beyond the statement of these bare facts, and that small charges were made use of.

In 1833, Mr. Abbinett, a celebrated diver, blew up part of the wreck of the "Boyne," off Portsmouth, with two charges, one of 630 lbs., and the other of 200 lbs. of powder. The large charge was held in an oil-hogshead, and was ignited by two slow matches each 45 feet long, protected by leaden-tubes reaching to the surface.

About this period also submerged charges of gunpowder were used at Plymouth in blasting rock; these were ignited by pieces of red-hot metal dropped down tubes from the surface.

The most important of the early demolitions were those of the brig "William" and the schooner "Glenmorgan," both of which foundered in the Thames near Gravesend in 1837, and that of the famous "Royal George," at Spithead. These removals, together with that of the "Edgar," at St. Helen's, were all executed by Colonel, afterwards Sir Charles Pasley, R.E.

Before undertaking the destruction of the wrecks in the Thames, Colonel Pasley recommended that efforts should be made to raise the sunken ships, and stated his opinion that it was preferable to weigh sunken vessels entire if possible, than to blow them to pieces, and weigh the fragments afterwards. Application was accordingly made to the Naval authorities, the result of which was, that the Master Attendant of Chatham Dockyard received instructions to lift the ships, and was despatched to Gravesend with the needful gear. After some weeks spent in fruitless labour, the attempt was given up on account of the great weight of the vessels, their cargoes consisting respectively of coal and iron; it was therefore decided to fall back upon the original plan of destruction by gunpowder.

Since the year 1812, Colonel Pasley's attention had been directed to the art of blasting under water, which was at that time very little understood, and he carried out a series of experiments with small charges of powder in the Medway, with a view to ascertain the best mode of ignition at considerable depths. Bickford's fuze had been used with great success in shallow water, but was found to be uncertain at depths of 10 or 12 fathoms; its slow rate of burning also rendered it objectionable. He ultimately came to the conclusion that

nothing was preferable to a small linen-hose filled with powder and enclosed in a leaden-pipe leading from the charge to the surface, and there supported by buoys. The hose burnt uniformly at the rate of 10 feet per minute, its diameter was $\frac{1}{10}$th inch and that of the pipe 1 inch. The top of the latter of course stuck out of the water, and after ignition, the smoke issuing from it, gave an unfailing indication as to whether the hose was burning properly.

Having settled this point, Colonel Pasley commenced his preparations. He determined to attack the "William" first, knowing her to be strongly constructed, having been built as a vessel of war. He proposed to use two large charges of gunpowder, each of 2,500 lbs., and placed on opposite sides of the ship, not exactly amidships, but one rather nearer the head and the other nearer the stern. These he anticipated would be sufficient for the purpose.

The cases to contain these large charges were built in Chatham Dockyard, and were similar in construction to large mooring buoys, but strengthened at the ends to enable them to resist the pressure of the water. Though of themselves perfectly watertight, it was deemed prudent to enclose within each of them a second water-tight cylinder of sheet lead, the dimensions of which were 3 feet in diameter, and 6 feet 2½ inches long. Three holes were provided in each cylinder; in the middle hole was inserted a short leaden tube, closed at the bottom, and perfectly water-tight. This tube was open to the outside and its closed end led to the centre of the great charge, with which however, the tube had no communication. The object of the tube was to hold a small bursting-charge, which should be ignited directly by the powder-hose, and by its explosion open the tube and fire the great charge. By this precaution the large mass of powder in the cylinder would be saved in the event of any accident happening to the lead tube and the water finding its way into the powder-hose, which would not be the case were the hose to lead direct into the body of the charge. The two other holes were for filling the cylinder with powder, after the completion of which operation they were hermetically closed by plates of tinned metal soldered over them.

The diving-bell and divers in helmets were employed in examining the wreck. The latter appear to have been found the most useful, the space covered by the bell being very limited. The apparatus was, however, much more clumsy than that now in use, and a corporal of the Engineers, who was the first diver sent down, became entangled at his second descent, and died before assistance could be rendered to him.

The operations were commenced by mooring a lighter immediately over the wreck. A strong rope, sunk by weights, was then led entirely round the hull, and the ends secured so as to clasp it tight. Pulleys had been previously attached to the rope at the points at which it was intended to lodge the great cylinders, and small ropes passing through them served as downhauls to get them into position. The depth of water was 60 feet. So unwieldy were the great cylinders that considerable difficulty was experienced in manœuvring the first and getting it down, but it was at last secured, and after clearing away

the lighter and small craft, the powder hose was ignited. Very soon afterwards the water got in at the top of the pipe and put the hose out, to the great disappointment of all concerned, as well as of the spectators, thousands of whom had congregated on the banks. Matters were further complicated by a large ship, which in the course of the night ran foul of the lighter and carried away the leaden tube. Next day the charge was raised and found to be dry, thanks to the small tube containing the bursting charge, which alone had suffered: it was therefore prepared with a fresh hose, again lowered, and fired successfully. The explosion destroyed so much of the wreck that it was not considered advisable to waste the other great charge in breaking up what remained, and the demolition was completed with smaller charges. A charge of 350 lbs. was prepared, contained in a tin case enclosed in a cask, but the water got in and drowned it. A similar charge was also lost in the same way. Finally the demolition was completed by fifteen charges of 45 lbs. each, enclosed in 5-gallon tin oil-bottles, and fired with short lengths of Bickford's fuze.

The schooner "Glenmorgan" was next examined. She had gone down several years before, and was not so much in the way as the other, indeed it is probable that had it been found necessary to expend the second cylinder upon the brig she would not have been blown up at all. The divers reported that she lay low in the mud, but that a gully had been swept all round her by the wash of the tide, reaching on the port-side nearly to her keel. Advantage was taken of this peculiarity, and the large charge of 2,500 lbs. was lodged in this natural trench exactly opposite the centre of the ship. The depth of water was not so great as in the other case, being only 40 feet at low tide. The same arrangements as before were made for firing, and after one failure due to a defect in the leaden tube, the charge was exploded successfully and completely dispersed the wreck.

The total expense of removing these two vessels amounted to £400. The operations excited a good deal of curiosity at the time, many people doubting the possibility of exploding gunpowder under water at all. The Lord Mayor and Court of Aldermen marked their approval of Colonel Pasley's success by presenting him with the freedom of the City in a gold snuff-box of the value of £50. It is a significant testimony of the advance of this particular branch of science that now, after 30 years have elapsed since this testimonial was presented, undertakings of the same nature, but on a much larger scale, are entrusted to junior subalterns of Engineers as part of their ordinary duty.

In his report, Colonel Pasley frankly admits that he was guided by no rule in determining the amount of powder required to effect demolition, which is plain from his evident intention of using 5,000 lbs. to blow up the "William," little more than one half of which quantity turned out to be enough. But it must at the same time be remembered that he had no former results to guide him, and feeling his way in the dark he was resolved to err in excess rather than fail in his object through unwise economy. Moreover, the laws of submarine explosions were at that time very little understood, and

the only available experience was derived from a small number of meagre experiments. Viewed by the light of our present knowledge, these arrangements present grave defects. Leaving out of consideration the method adopted to ignite the charges, we see that the same amount of powder would have done much more work had it been used in smaller quantities. In all descriptions of submarine explosions, a great point is always made of the vast column of water and mud, of such and such estimated diameter and so many feet high, thrown up into the air, the writers appearing to overlook the fact that the object of the explosion is not to raise the greatest possible column of water, but to do the greatest possible amount of work below, and that such a column represents with tolerable accuracy the quantity of power wasted. This being the case, it is now usual to regulate the size of charge by the depth, using such a quantity as just fails to break the surface of the water, by which means the maximum of effect is obtained. Cases sometimes occur in which it is expedient to deviate from this rule, for instance in very shallow water, where charges so calculated would be too small, but it is acted on as a broad principle.

Another objection to these charges of a ton weight is this: a case which would hold the powder and keep the water out, appears to have been considered perfect. Now we know by actual experiment that gunpowder does not explode instantaneously, but that its combustion proceeds at a very rapid rate from the point of ignition through the whole mass. In the case of a charge fired under water, unless a very strong envelope is used to confine the explosion, as it were, and allow the whole mass to ignite, the firing of the first half dozen pounds is sufficient to open the case, when the water rushes in and drowns a large proportion of the rest. The evil is partially remedied by providing a great number of centres of ignition, whereby the charge can be fired at many points simultaneously, but even this artifice does not remove the necessity for great strength in the external case. A number of experiments on this point have been carried out in connection with the question of torpedoes, from which it appears that unwieldliness and weight are the only considerations which limit the strength that may be advantageously given to these envelopes. It has been also laid down that 250 lbs. of powder is the maximum which should ever be fired from one centre. I have no hesitation in saying that of the 2,500 lbs. in each of Colonel Pasley's cylinders, not one half exploded.

Encouraged by the success which had attended him in the destruction of these two wrecks, Colonel Pasley was induced to undertake the formidable task of removing the "Royal George." The history of this ill-fated vessel is well known. Suffice it to say that she lay at the bottom at Spithead in 80 feet of water, and had for half a century proved a great annoyance to mariners from the frequency with which she was fouled by the anchors of ships bringing up in the roadstead.

Before sending in his estimate of the probable expense of this great work, Colonel Pasley instituted a series of experiments at Chatham,

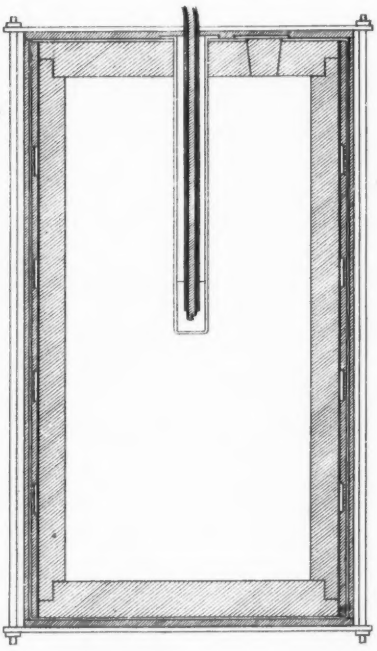
to determine the form of diving-bell best adapted for employment in a strong tideway, and also the feasibility of applying voltaic electricity as a means of igniting submerged charges. The first question was settled to his satisfaction by the addition of pointed ends to the original square form of the bell, the result of which was, that perfect steadiness was secured in a current running 3½ knots an hour, a velocity considerably greater than was known to exist at Spithead.

With reference to the adoption of voltaic electricity for the firing of gunpowder, I may mention that this method depends for its principle on the heating of a small filament of metal by the transmission of a powerful voltaic current, which effect is due to the resistance offered to the current by the minute sectional area of the conductor, through which it has to pass. Platinum is the metal best suited to the purpose, as its great ductility allows of its being drawn into very fine wire, and the high temperature at which it fuses, permits it to become white hot without breaking. The principal drawbacks to the employment of this fuze are these. It can only be used within a comparatively short distance of the battery, as the resistance of the main conducting wires is so great, that the current rapidly loses its energy as the length of the conductors which it has to traverse is increased. To generate a current of sufficient quantity, a large battery must be used, involving the employment of jars to form the cells, and bottles to contain the acids, which, for rough work, are liable to get broken, while at sea the liquids are apt to be spilt. It is impossible to ascertain the state of the fuze, or conducting wires, by testing after submersion. Still, in spite of these disadvantages, the employment of the platinum-wire fuze was a great step in advance of the powder-hose or Bickford's fuze, and the result of the experiments was, on the whole, so much in its favour, that it was decided to employ it at Spithead, using for conductors insulated copper wires of ¼th inch in diameter, and for the source of electricity, Professor Daniell's constant battery. It was ascertained that fourteen cells of the pattern adopted were capable of firing powder at a distance of 2,000 feet.

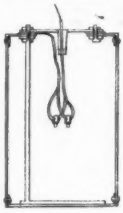
Fully satisfied with these results, Colonel Pasley framed his estimate, amounting to £2,500. It was known that the value of the guns alone of the "Royal George" was £5,000; so that, supposing only half to be recovered, the work would pay itself.

As soon as the necessary authority from the Board of Ordnance had been received, four large cylinders were ordered to be built at Chatham Dockyard, capable of containing 2,500 lbs. of gunpowder each, the same size, in fact, as those used in the Thames. An improvement was, however, introduced, by the transfer of the leaden protection from the inside to the outside, it being evident that, with the old cylinders, in the event of water penetrating the external wooden case, the pressure would inevitably collapse the flexible lead (as actually happened with two charges of 350 lbs. sunk on the wreck of the "William"), and the object of the latter would, therefore, be defeated, whereas by using the lead as a skin to the wooden case, no such thing could occur. Each cylinder was 6 feet long and 3 feet in diameter, internal

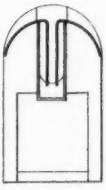
Section of Wooden Case to hold 2,500 lbs of powder, as used to destroy the "Royal George".



Section of Iron Case to contain 90 lbs of Guncotton

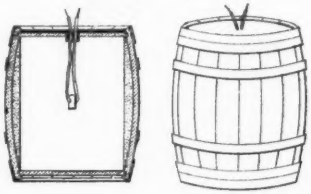


Abel's Fuze (Section)

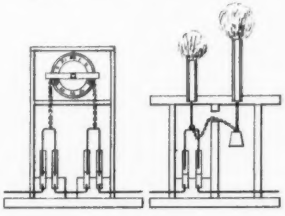


Scale $\frac{2}{3}$

Section and Elevation of charge of 60 lbs of Guncotton, used to destroy the "Tredes"



Contrivances for making and breaking circuits with Voltaic Battery, used in India.



Scale $\frac{1}{24}$

1 ½ 0 1 2 3 4 5 Feet

J. Jobbins.

measurement; the thickness of the sides was 4 in., and of the ends 5 in., and the whole was bound together with four iron hoops. To protect the leaden skin from accident, wooden battens were fixed on the outside, canvas bags being used to fill up the intervals, and lastly the entire cylinder was wound round with a woolding of unserviceable rope. The leaden tube to contain the bursting charge was introduced from one end instead of from the side, and was 3 feet long, reaching to the centre of the charge, the loading hole being at the opposite end.

When these were completed, forty 5-gallon tin oil-bottles, capable of holding 45 lbs. each, were procured from the Tower, and were stowed along with the great cylinders, and the necessary stores, tools, and apparatus in a Navy lighter. Captain Williams, R.E., with a detachment of Royal Sappers and Miners, embarked in the same vessel, and set sail for Portsmouth on the 17th August, 1839.

While these preparations were going on at Chatham, arrangements were being made at Spithead for the commencement of active operations. A large dockyard mooring lighter was anchored on each side of the wreck, their distance apart being about 600 feet, and a number of careful soundings were taken, proving that the highest part of the wreck stood 33 feet above the ground, the depth of water at low water spring tides being 80 feet. Divers were also employed to examine and report upon the condition of the ship.

Armed with this information, Colonel Pasley proposed to fire his four great charges against the two sides of the wreck in pairs, not exactly opposite one another, but chequerwise making the interval between the charges on the same side 60 feet, the idea even crossed his mind of firing the whole four simultaneously; but this he luckily abandoned, and there is little doubt that had he attempted to do so, his electrical arrangements alone would have proved unequal to the task. He therefore determined to commence on the north side with two charges, and to reserve the others until their effect had been ascertained. The principle of hauling down, for placing the charges in position, had already proved successful; chain sweeps, with single sheave blocks, attached at proper intervals, were therefore sunk, and with some difficulty secured round the hull, while, in the mean time, the loading of the cylinders progressed. The several downhauls became entangled soon afterwards, and on the day fixed for the first explosion, only one could be got to work. A third lighter, with the charge on board, was warped into position between the other two, and the cylinder having been attached to one end of the only available downhaul, the unwieldly mass was drawn into its place, and there secured; the vessel containing the battery then moved off, paying out the conducting cables to nearly their full extent of 500 feet. When all was ready, the word was given to fire; but on completing the circuit nothing took place, and it was evident to all that the mine had failed.

A curious fatality appears to attend submarine demolitions, and was especially remarkable in the constancy with which it followed Sir Charles Pasley. Great as was his experience, his most important explosions almost always failed at the first attempt, though attributable

to perfectly preventible causes. This was especially annoying, as crowds of spectators invariably assembled, among whom were generally the local Naval and Military authorities, and occasionally a Lord of the Admiralty, or some equally distinguished visitor. It seems strange that such people should congregate to see a splash, for the whole spectacle consists of nothing more, and in a judiciously executed demolition, as I have already shown, even this should not be seen.

As soon as possible after this failure, divers were sent down to recover the great cylinder, but for several days their utmost endeavours to liberate it were unavailing, and it was not until it had been under water for a week that it could be got to the surface. It was then discovered that the cause of non-ignition was a defect in the bursting charge, which proved to be wet, and the bad insulation of the wires, a matter of secondary importance with this form of fuze. But the most serious part of the misfortune was, that the water had forced its way into the body of the cylinder, and the whole ton of powder was spoiled.

In the course of the week, several small charges were fired in the oil bottles, for the purpose of testing their resistance to the pressure. Bickford's fuze was used for some, and the battery for others, and they all went off satisfactorily. Bickford's fuze was applied in short lengths of 4 or 5 feet, and lighted at the surface, after which the charge, with the fuze burning, was sunk with a sand bag. Experiments were tried to ascertain whether oil casks were strong enough to be used as cases, but they were invariably stove in by the pressure of the water after a few hours' submersion; means were therefore adopted to strengthen their heads, when they were found to answer well, and were largely used at a subsequent period. A variety of other cases, of different materials, were subjected to the same test, several forms meeting with approval; of these, the best was the service Nun buoy, which held 120 lbs. of powder.

On the 4th September, five days after the recovery of the cylinder, another attempt was made, which also failed, and again the charge was found to be partially drowned. Very severe comments were at the time passed upon Colonel Pasley when the news became known, and it was considered that he had undertaken more than he had power to perform. Still his confidence in his own ability did not desert him, and he left orders that none but small charges should be expended until the great cylinders had been severely tested. The plan now pursued was for the divers to sling any loose fragments they could come across, using small charges to dislodge portions which could not be moved by the machinery in the lighters above. On one occasion only did any portion of the wreck float, for the timber was heavy and waterlogged with years of immersion, and required powerful purchases to raise it. Now and then a medium-sized charge of 250 lbs., in a wrought-iron case, was fired, and by these great execution was done, so much so, that twenty such cases were ordered to be made, and were expended in the course of the work.

On the 23rd September preparations were once more made to fire one of the monster charges; the same method was adopted as

before, and this time with success, a grand explosion taking place. Of course the attendance of spectators was not so great as on the occasions of the two failures, for people were weary of disappointment; those who were present were, however, highly gratified, and it is related that when the fragments of the wooden cylinder floated to the surface, a scramble to secure them ensued, and they were carried off as relics of the "Royal George."

The result of the explosion was to create a wide breach in the wreck, and a crater in the mud outside, about 8 feet in depth, enabling the divers to sling a number of beams and other fragments, besides several guns; and from long practice they became so expert, that the work was little more than a mere matter of routine.

The wooden cylinders having turned out badly, a large case was ordered to be made of sheet-iron, in a fashion similar to the medium-sized cases which answered so well, its shape was cylindrical, with conical ends, the total length being 8 feet. A charge of 2,300 lbs. was fired in this case under the ship's bow, then the most perfect part, on the 14th October, after a failure of the same charge a few days before, when, however, the powder escaped uninjured. A great mass of wreck was loosened by the explosion, and recovered by the divers, a few small charges being occasionally expended to hasten the removal of obstinate fragments. The party continued working till the end of the month, when from the setting in of bad weather, the operations were suspended, and postponed till the commencement of the following season.

It is unnecessary to follow further the history of this arduous and tedious undertaking. The same system continued to be pursued throughout the warm seasons of 1840 and 1841, that had met with such excellent results in 1839, and it was not until three years had been spent, that the last pieces were removed, and the roadstead was finally cleared of the obstruction, with which it had been so long encumbered.

Probably no demolition has ever been so completely effected as that of the "Royal George." It seldom occurs that a ship is wrecked at an anchorage, and it is only in such a situation, or in the midst of an important fishery, that it becomes a matter of necessity to remove the pieces at all, as the act of breaking up and dispersion produced by the judicious use of certain charges, is, generally speaking, enough to satisfy the demands of navigation, especially in places which are subject to strong currents or tides, the levelling effect of which on rough surfaces soon makes itself apparent. Care must, however, be taken not to rely too confidently on the force of a current; a ship contains too much solid and heavy material to be so easily disposed of, and though most reports of these operations wind up with some such assertion as that "nothing now remains but a few insignificant frag-"ments, which the next spring tide will wash away;" such conjectures should be received with caution.

The great charges of powder made use of, though much more suitable on this occasion than in the shallower water of the Thames, might still have been reduced considerably with advantage, but nothing could

have been better than the way in which the medium-sized and small charges were applied, and no fault can be found with the arrangements made for securing and weighing the detached fragments.

With regard to the diving operations, it appears that the use of the bell was soon abandoned, and the work left to the helmet-divers, whose freedom of action was comparatively unimpeded. The perfection which has now been reached in the manufacture of diving apparatus, has rendered the use of the bell obsolete, except for such purposes as laying foundations, and even here its advantages are doubtful, and its drawbacks great.

Simultaneously with the blowing up of the "Royal George," a similar operation, on a much smaller scale, was going on in India. The barque "Equitable," 420 tons burden, with a cargo of wheat and rum, was wrecked in the Fultah reach of the Hoogly on the 4th October, 1839, having grounded upon a newly-formed sand-bank in the middle of the river. She was thrown on her beam-ends by the current, and foundered. The depth of water over the wreck varied from 15 feet to 30 feet, according to the state of the tide.

Attempts to break her up proving abortive, it was ultimately settled to blow her up with gunpowder. The plan of operations decided upon was to lodge against the vessel a large charge of powder, and to ignite it by means of a powder-hose in a leaden tube in the manner first suggested, and put into practice by Sir Charles Pasley.

The cylinder to enclose the charge was made to contain 2,400 lbs. of powder, and was constructed of wood like a cask, and bound round with bands of iron; it was also enclosed in sheet lead carefully soldered at the joints. It was loaded through a small hole at one end, which was afterwards closed by a piece of lead, soldered over it. The leaden pipe was introduced into the cylinder through a water-tight joint of brass, and various minor precautions were taken to render the charge secure.

On the morning of 6th December, 1839, an anchor-boat with the large cylinder slung under her bows, was moored over the wreck in such a position that the charge, when lowered, would rest against or be close to the deck, and between the fore and main masts. As soon as the charge had been lowered, the anchor-boat slipped her moorings and the port-fire was lighted, but failed to fire the hose; a second port-fire did better, and the hose began to burn well; unfortunately, the quantity of powder in it was too great for the strength of the leaden pipe, the latter burst, water poured into the cylinder, and the charge was drowned.

After this accident, it was determined to employ the Voltaic battery, instead of powder-hose, as the firing agent.

As I have already mentioned, one of the principal drawbacks to the use of the platinum-wire-fuze is the necessity of having short conductors, unless the battery is very strong. In the present case, so bad was the form of battery used, that ignition could only be ensured at a distance of a few feet. To get over this difficulty, a small boat, containing the Voltaic battery, was moored immediately over the cylinder, and the wires from the fuze were led into her, so that the

length of the wires being little more than the actual depth of the water, was reduced to a minimum.

A piece of mechanism was attached to an ordinary clock, which could be arranged to complete the battery circuit after the lapse of any required interval of time, and having continued the contact for a period amply sufficient to heat the platinum-wire in the charge, to break it again, and so disconnect the fuze from the battery. In this manner the clock could be started, allowing time for the operators to get away; it would be known when to expect the explosion, and, in case the charge failed to go off, it could be examined with safety, when the interval necessary for breaking the circuit had elapsed. However, the latter part of the performance never took place, for the charge exploded, and it is needless to say that boat, battery, and clock shared a watery grave. The result appears to have been considered satisfactory; an examination of the wreck showed that nothing but the fore-part remained, and this it was resolved to break up by another explosion.

A second cylinder, similar to this first, was prepared, and loaded with 2,050 lbs. of powder; the other arrangements were precisely as before. From some unexplained reason, however, the charge did not explode; in all probability there was a metallic contact between the conducting wires short of the fuze, enabling the current to return to the battery without passing through the platinum-wire. The cylinder was raised, and the powder found to be dry; new conductors were therefore applied, and the charge once more lodged in position. This time it was endeavoured to save the boat containing the apparatus by stationing her as far as possible from the charge, consistent with the probability of firing the fuze, and another device instead of the clock, for completing and breaking the circuit, was adopted, which is worth mentioning from its ingenuity. Two portfires of different lengths, calculated to burn respectively for five and eight minutes, were inserted into a piece of wood. A metal fork was suspended from the bottom of the shorter portfire by a piece of string, in such a way that when reached by the fire, it should be burnt through, allowing the two branches of the fork to drop into two cups of mercury placed below, completing the circuit between them. A weight was hung from the bottom of the longer portfire in a similar manner, which by its fall would raise the fork out of the cups, and so break the circuit.

This charge exploded, and appears to have completed the demolition, as soundings, taken immediately afterwards, proved the channel to be free from obstruction. The expense of these operations amounted to £261 12*s.* 6*d.*

This demolition may be characterized as an employment of brute force unskilfully applied. The author of the design was evidently servilely following Sir Charles Pasley, without considering the necessities and circumstances of the case, or adopting many of his useful precautions, and by using charges of a ton weight in water so shallow as 30 feet, the waste of power must have been preposterous.

Colonel Crawley, R.E., has furnished an account of the destruction by him of the brig "Blemdel." This vessel was of 160 tons burden,

laden with slates, glass, and coal. She sank in the Mersey, in 1845, in 70 feet of water, and became so serious an obstruction to the anchorage that it was found necessary to remove her.

A diver was employed to examine the wreck; he found her partially imbedded in the sand, a deep gulley having been washed on the starboard side by the tide, extending down to the keel. An eyebolt was screwed into the ship's bottom by the diver as near the keel as he could reach, and a single block hooked into the eyebolt, a rope had previously been led through the block, and by means of this the charge was hauled down into its place from the surface. The first cylinder contained 300 lbs. of powder; it was arranged to be fired with a platinum wire-fuze; the conductors leading to the fuze were as usual carried into a small tube of lead fixed into the cylinder, and containing a bursting charge of ½ lb. of powder.

The first attempt to fire the charge was unsuccessful, the bursting charge having got wet, the powder in the cylinder remaining dry. Greater care was taken the second time, and the charge exploded, demolishing the fore part of the ship. A second charge of 400 lbs. was afterwards lodged in the after-hold, some of the cargo being removed to form its bed. After it had been fired, the obstacle was reported to be removed.

A great portion of it must have sunk in the mud, otherwise the quantity of powder would have been quite insufficient. The power was, however, applied economically, and the charges must have done as much work as could be got out of that amount of powder.

The most extensive operations of this nature that have yet been carried out, were the demolitions of the ships sunk in the Hoogly, in the vicinity of Calcutta, during the great cyclone of the 5th October, 1864. Lieutenant Wallace, R.E., was the Officer employed, and it appears, from his report, that no less than fourteen large ships, several of which exceeded 1,000 tons burden, were blown up by him in the course of 1864 and 1865. His large experience is of great value, and his report, printed in the professional papers of the Royal Engineers, gives the fullest details of the plan of operations pursued. It was briefly as follows:—Having ascertained the position of the wreck to be operated upon, its position was accurately marked by buoys attached to the bow and stern, and other important points, such as the hatchways and masts. This service was performed by the native divers. Several moorings were then laid out in convenient positions round the wreck, and about 50 yards from it; the use of these was to warp the boats into any position required for lowering charges. The method of lodging these depended upon circumstances. When the vessel lay on an even keel, it was generally contrived to place them inside, by sliding them down bamboos introduced into the hatchways. Recourse was also had to this artifice to place the charges under the keel of a ship lying on her beam-ends up and down stream. In the case of a vessel sunk across the stream, the placing of the charges was effected by the current itself. The time selected was just before and just after low water, a charge being lodged on the upper side on the last of the ebb, and on the lower side by the first of the flood; the two charges

were then connected and fired simultaneously, and from this method excellent results were obtained. Lieutenant Wallace used three different sizes of charges, viz., 500 lbs., 300 lbs., and 150 lbs., enclosed respectively in hogsheads, half-barrels, and kilderkins, and he appears to have appreciated the advantage gained by proportioning the charge to the depth of water. The smaller charges were made use of for depths not exceeding four fathoms, beyond which the heavier ones came into play. He states his opinion, that at nine fathoms, 500 lbs. might be increased with advantage, and this is fully borne out by recent experiments made in this country.

Some difficulty was met with, owing to the strength of the tides, and the bore, to which the Hoogly is subject, which, from the violence of its action, necessitated the firing of the charges soon after they were placed, whereby the advantage of the head of water gained at high tide was lost. The barrels containing the charges, when used at a greater depth than 3 fathoms, required strengthening at the ends to enable them to withstand the pressure of the water. Several failures occurred from this cause, in spite of the precautions taken. When the ends of a barrel had been strengthened, a leaden bursting tube was inserted, and the whole was then payed over with a mixture of pitch and tar, sewn up in strong canvas, and again coated with composition. The barrel having been loaded, a small bursting charge was placed in the lead tube, the fuze inserted with its wires attached, and the upper part of the tube filled up with Kitt's composition—stuff something like putty—and rammed hard with a stick.

The fuze employed was that invented by Mr. Abel, for explosion by the passage of electric currents of high tension, such as are generated by a frictional electrical machine, or a series of magnets revolving before fixed armatures, or by an induction coil. It consists of a hollow wooden body, the cavity of which is primed with gunpowder, and contains, at its upper extremity, a small capsule filled with a mixture of certain salts, into which the two wires are introduced, separated, however by the mixture. The latter is ignited by the passage of the electric spark, as it leaps from one terminal to the other through the mixture, and, kindling the powder in the cavity, fires the charge. This form of fuze possesses the great advantage over the old platinum wire, that it can be exploded at almost any distance from the firing battery, provided the insulation of the conducting cable is good. It is also fired with a small portable instrument, dependent for its action only on the turning of a handle, and not liable to get out of order, thus dispensing with the use of a clumsy or fragile battery. It can also be tested electrically with a galvanometer and small battery, after the charge has been lodged, and the test so obtained will indicate whether the cable and fuze are in a satisfactory state, and whether the charge will explode, a most important point to secure, but one which it is impossible to explain without entering into the principles of electrical science. The fuze has many other advantages, which it does not now come within my province to enumerate.

The battery used to fire the fuzes by Lieutenant Wallace was one of Siemen's magnetic transmitting instruments, a machine similar in

principle to the well-known magnetic exploder of Professor Wheatstone, and consisting of a powerful permanent magnet, the current being generated by the rapid revolution of an armature between its poles. The conducting cable was a copper strand insulated with gutta-percha; it was found troublesome, from the melting of the gutta-percha by the sun.

The total number of charges used to destroy the fourteen ships was 160, containing an aggregate of 52,420 lbs. of gunpowder; of these, 21, containing 7,010 lbs., were drowned, the loss thus amounting to a little more than 13 per cent.

There can be no doubt that less powder would have been used had professional divers been available, so that the charges might have been placed in situations where their destructive effect would be most felt. As it was, the only divers procurable were the natives, who could not stay under water for much more than a minute at a time.

Our latest experience has been gained in the blowing up of the iron steamer "Foyle," in May, 1868, and the wooden schooner "Iredes," in November of the same year.

The former was a vessel of about 700 tons burden, and was sunk in the Thames, at Barking, and near the Essex shore. She had been down for about two years, during which time efforts had been made to lift her, but without success. She lay on an even keel obliquely across the stream, at low water the deck of the fore part dried, and at high water there was a depth of 40 feet all round her. Having lodged on a hard bank, her back was broken, and both bow and stern were sunk considerably below the level of the centre part, which rested on the ridge, the stern, however, being the lower of the two. An examination made by divers showed that the hull was otherwise perfect, with the exception of the loss of part of the deck, and a few trifling injuries produced by the explosion of some very small charges of powder, and that it was not at all imbedded in the bottom, the nature of which was hard peat. The reason of this was, that the tide, which here runs with great strength, had washed a gully all round her, throwing up a bank on either side.

To effect destruction, it was decided to use six large charges of 300 lbs. of powder each, and as many small ones of 100 lbs. as would be required to complete the demolition. 300 lbs. was selected as a quantity well suited for a depth of 40 feet of water; and in order to develop the full force of the powder, each charge was enclosed in a case of $\frac{1}{2}''$ boiler plate iron, rivetted, and fired by two fuzes at different points. By thus providing two centres of ignition, and a case capable of resisting a considerable internal pressure, it was ensured that the maximum amount of work of which the charges were capable would be secured. As an additional precaution against drowning, the actual powder was put into a strong bag of vulcanized india-rubber, and sealed up hermetically; the bag was then dropped into the iron case, and the top of the latter fixed on with bolts and nuts, also rendered watertight by a washer of india-rubber.

The result of these precautions was, that none of the powder was damaged by water; for though, in one instance, an iron case did let

the water in after an immersion of twenty-four hours, the india-rubber bag saved the charge, which went off as well as the others.

Spectators came at different times, but were much disappointed, on one occasion from a failure of the attachments of a charge, whereby it got out of place, so that firing it would have been waste; and on others, from not seeing the expected column of water; or, as was anticipated by some, portions of engines, boilers, iron plates, and interior fittings, thrown high up into the air. The actual effect of an explosion was simply a shock, and a slight heave of the water immediately over the charge, amounting, perhaps, to 3 feet in vertical height, succeeded by the rise of such fragments as were light enough to float.

On one occasion, a pair of 300 lbs. charges were exploded simultaneously; they were situated opposite one another, and abaft the engines. The result was good; on both sides of the ship the plates were torn and broken for a considerable distance from the position of the charge, and it turned out that, by their united action, the whole after-part of the ship had been lifted bodily, and let drop again.

In all cases, the charges were secured to chains, which had been originally passed under the ship's bottom for the purpose of lifting her. A small rope was led by the diver through the lowest link of the chain which he could reach, and this, when brought to the surface, served as a downhaul, by which the charge could be placed in position, and then lashed. The cases were cylindrical, 2 feet in diameter, and 3 feet high, and weighed, when full. 6 cwt. each.

Just at the time that this demolition was going on, Professor Abel, chemist to the War Department, had brought to a conclusion his labours and investigations relating to the preparation and properties of gun-cotton, and had at length produced it in the compact form in which we now use it. Mr. Brown, of the Chemical Department at the Royal Arsenal, had also just made the wonderful discovery of the force exerted by this substance when fired by detonation. To make these points clear, I must digress in order to review very briefly the history of this remarkable explosive compound. It was discovered in 1846 by Schönbein, and experiments on a considerable scale were conducted to ascertain whether it could be advantageously employed as a substitute for gunpowder. Compared with the latter, it certainly seemed preferable for use in small arms and ordnance, as well as for mining purposes, from its freedom from smoke and solid residue, and from the great amount of force which could by its means be concentrated into a small space. A Committee was appointed in Germany to report upon it, which, at the close of its investigations, pronounced against it, and for the time it was abandoned. The manufacture was soon afterwards taken up by Messrs. Hall, the gunpowder manufacturers of Faversham; but a terrible explosion, by which many lives were lost, discouraged them to such an extent, that they also gave it up. Simultaneously, the French started two manufactories, both of which met with a similar fate. All this happened twenty years ago. To Baron von Lenk, of the Austrian service, is due the credit of first bringing the material into practical use, by producing it in a compact and tolerably safe form, so much

so that it was introduced, and largely used, in the Artillery and Engineer services in that country. Still, as late as 1862 a disastrous explosion occurred near Vienna, proving that gun-cotton was not yet completely mastered.

It is hardly necessary to say anything with reference to the manufacture of gun-cotton, except that on the manner in which the various processes are carried out, and the care exercised at all stages, depends the stability of the resulting explosive, and consequently its security from spontaneous combustion, and safety when stored. By the action of concentrated nitric acid upon pure cellulose, a certain number of atoms of hydrogen in the latter are replaced by a corresponding number of atoms of peroxide of nitrogen, the number so exchanged depending on the strength of the acid employed. The highest of the substitution products so formed is that known to chemists as trinitrocellulose, and this is pure gun-cotton, as now manufactured. The lower substitution products are all found to decompose after a certain length of time, when exposed to peculiar conditions, and it was to this cause that the explosions which were so severely felt in the infancy of gun-cotton, owed their origin.

Baron von Lenk discovered that the nature of the explosion of gun-cotton could be regulated by the form in which the material was made up, and that when loosely disposed, it exploded with less violence than when compressed into a small space. He therefore brought it out in the form of yarn, and afterwards of plaited or twisted rope, which for a cartridge for artillery purposes was wound round a hollow wooden core, occupying a considerable space, so as not to injure the gun by too rapid ignition. For mining or blasting, on the contrary, the yarn was rammed tight, and strongly enclosed, the effect of which was to develop the force in its most destructive shape. At this stage of its progress the improvement of gun-cotton was taken up by Mr. Abel, who experimented largely with it in all the forms which were at that time known, and thoroughly mastered the theory of its combustion and the numerous attendant phenomena for which it is renowned. Among other points, he discovered that it was susceptible of two totally distinct kinds of combustion, the one rapid, producing explosion when confined, and the other so slow as to resemble smouldering. A lecture delivered by him at the Royal Institution in 1864, and printed in the proceedings of that body, contains a description of his experiments and the conclusions drawn therefrom, and possesses the highest interest. By these investigations Mr. Abel was led to improve upon the old-fashioned yarn, which I may remark was used by the Austrians in torpedoes for the defence of Venice in the last war, by reducing the gun-cotton when wet to a state of pulp similar to that used in the manufacture of paper, and afterwards forming it into discs or cakes under a pressure of from 4 to 5 tons to the square inch. These cakes, when dry, constitute the substance as now used. By the act of compression its specific gravity becomes nearly equal to that of powder, enabling a given weight of charge to be contained in one quarter of the space that would be required for an equal weight of any of the varieties of looser texture. Still it had this disadvantage. To explode it, it was

necessary to confine it in an envelope of great strength, for when ignited in the open air it simply burnt like an ordinary inflammable substance, and until Mr. Brown applied the detonating explosion of fulminates as the means of ignition this drawback was greatly felt. Now, fuzes are issued precisely like those originally brought out by Mr. Abel for use with electricity of high tension, but primed with fulminate of mercury instead of powder, and these are always used to fire charges of gun-cotton, which, when so ignited, explodes even if perfectly open to the air, with as much violence as if confined in the strongest case. It has been remarked that the action of gun-cotton is sympathetic, for when lighted with a spark it smoulders, with a flame it burns, and with a detonator it explodes violently.

We have lately had many instances of the detonation. Being tried for the purpose of blowing in stockades, it was found that solid timbers of oak or fir, 13 inches square and strongly backed, could be cut through without fail by the explosion of 7½ lbs., simply piled loosely against them on the ground level. The action appears to be purely local, and the effect almost resembles a horizontal cut, so small is the damage produced both above and below the position of the charge. There can be no doubt that advantage might be taken of this action for cutting down trees, if it was required to fell a large number in a short time. But still more marked are the effects of detonation under water. A charge of gun-cotton, weighing 3½ lbs., fired at a depth of 7′ 6″, in that way gave a very perceptible shock to Her Majesty's ship "Hercules," at a distance of 400 yards, and such a quantity will kill and bring to the surface every fish within 100 yards. Neither of these effects have been experienced even with 20 or 30 times the quantity of powder. I do not mean to say that it represents an equivalent to such a proportion, but that the effects of the two are very different in character. The equivalent usually calculated on, is 1 of cotton to 4 of powder, weight for weight, when used for submarine purposes; and that it is fully up to this we have ample proof.

To return to the "Foyle." It was thought a pity to let so good an opportunity slip of testing practically the value of this terrible explosive. The last of the six cylinders was therefore filled with cotton, 260 lbs. being the quantity. The fuze employed was a common powder fuze, but the gun-cotton acted explosively, on account of the great strength of the iron case in which it was enclosed. The charge was lodged opposite the engines, the strongest part of the ship, in a spot where one of the 300 lbs. powder charges had been previously fired without producing any result at all. The effect of the explosion was remarkable. The shock was most violent, and very different in its suddenness from the comparatively slow heaving force of gunpowder. The engines were completely broken up, and a breach made in the ship which the divers were unable to examine, owing to the tangled mass of twisted and broken iron bars and plates which lay in a confused jumble at the bottom, for it must be borne in mind that the wreck lay nearly opposite the great sewage outfall, and the water was in consequence so filthy that a diver at the bottom worked in absolute darkness. Indeed, on a previous occasion he was in a serious predicament,

for groping along where a charge had been fired, his life-line was caught in the jaws of a torn plate, and being unable to free it, he came up hand over hand on the air tube.

The experiment was conclusive as regards the expediency of using gun-cotton for submarine explosions. There is little more to relate with reference to the "Foyle." After the explosion of the great charges, five smaller ones of 100 lbs. each, in tins were sunk in various places. One was drowned from a failure of the tin, and the others exploded. They were used wherever it appeared that portions of the wreck were hanging together, and their effect was excellent. It was difficult to determine the exact condition of the wreck at the close of the operations, from the impossibility of employing divers: preparations were however made to raise the detached fragments by the agency of a powerful steam dredger, which I believe to be at work still. The time occupied in the actual blowing up was two months, including a long delay while the iron cases were being made. The expenditure of explosives was—

Gunpowder	.. ..	2,000 lbs.
Gun-cotton	.. ..	260 lbs.

The working party consisted of one serjeant, one corporal, and five men of the Royal Engineers. I was in charge, and had the immediate superintendence of the work, acting under instructions from the School of Telegraphy and Submarine Mining at Chatham. A professional diver, lent by the Naval Authorities of Chatham Dockyard, was employed; the serjeant of my party also dived, and soon became expert, and we all went down at different times for practice. The corporal was employed as electrician and had charge of all the arrangements connected with the loading and firing of the charges. The battery used was Baron von Ebner's frictional machine, and the conducting cable a 7-strand copper wire, insulated with coatings of vulcanized india-rubber and other substances, and known as Hooper's core.

The results of the large charge of gun-cotton fired against the "Foyle," and of comparative experiments subsequently carried on in the Medway, were so satisfactory, that when, in October, 1868, a request came from the Trinity Board that the wreck of the schooner "Iredes" might be blown up, it was thought advisable to use it exclusively, in preference to powder.

It had been conclusively determined, that for the purpose of submarine mining, the value of gun-cotton was not less than four times that of powder, while its cost was three times as much, weight for weight; consequently its employment entailed an absolute saving in the cost of the explosive agent of 25 per cent. When, in addition to this, it is remembered that a charge of gun-cotton occupies one-third the bulk of a charge of powder, capable of doing the same amount of work, that when fired by detonation it does not require a strong case, but simply a water-tight envelope, and that in the event of its getting wet, it sustains no permanent injury, but is as good as ever when again

dried, it will be clear, that the advantages attendant upon its employment are very great.

Four charges to be used against the "Iredes," were prepared as follows:—Cylindrical tins were made, 19 inches long and 15 inches in diameter, just to fit inside 12-gallon casks. Each tin, after being filled with 60 lbs. of gun-cotton, and provided with a detonating fuze, was soldered up. This operation had to be performed with care, as gun-cotton explodes at a very low temperature. The two wires from the fuze passed out through a nozzle of tin secured to the top of the cylinder, in which they were hermetically fastened by a bung and a quantity of pitch poured in hot and allowed to cool. The tin was then dropped into its barrel, and rammed all round with sand, to give it steadiness and weight, and, lastly, the barrel was headed up, the tin nozzle passing through a hole in the top, and all cracks and apertures were filled up with hot pitch.

The wreck was on the Cant sand, three miles below the Nore; she was a small wooden vessel, laden with slate. The work of examination by divers, and placing of charges, was performed by men from the Engineer barracks at Chatham, who went down each day in a naval steam launch. The time of year, being winter, was very unfavourable, especially as the wreck was more than three miles from the nearest land, and the work was all carried on from an open boat, and was, moreover, 25 miles from the base of operations.

From these causes great trouble and delay ensued, for it was impossible to work in rough weather, and valuable time was lost in coming and going, which could ill be spared from short November days. However, by the end of the month the four charges had been expended, three on the starboard side at equal intervals, and the fourth near the bow on the port side. Gales set in at the beginning of December, which rendered it necessary to abandon the work, and it was resolved to delay its completion till the commencement of fine weather in the ensuing spring.

On the 3rd April last we were able to proceed to the spot, and an examination, lasting three hours, proved the wreck to be completely broken up, the *débris* being scattered over the sand. As far as navigation is concerned, therefore, the obstruction has been practically removed by the expenditure of 240 lbs. of gun-cotton; but for the sake of the fishery it has been decided to weigh these fragments, for which purpose a lighter with suitable gear will be provided.

Although gunpowder and gun-cotton are the only explosives which have as yet been applied to the demolition of submarine obstructions, there are various others which might be used for this purpose. The chief of these are nitroglycerine, glyoxyline, and dynamite. The first of these has the pecular advantage that its explosive power is not impaired by the entrance of water, so that a small leak in the enveloping case would not of necessity cause a charge to fail.

On the other hand, it possesses serious drawbacks, such as a tendency to explode spontaneously when stored, and to congeal at a very moderately low temperature, in which state it is liable to go off with a blow.

Glyoxyline is gun-cotton soaked in nitroglycerine, of which liquid it will absorb its own weight. It is subject to many of the disadvantages of nitroglycerine, and, like it, is very poisonous to handle. Its effects, when fired with a detonating fuze, are very similar to those of gun-cotton, but rather more powerful.

Dynamite is a mechanical mixture of nitroglycerine and sand, and was introduced for the purpose of obtaining the force of the former in a solid state. It presents no advantages over gun-cotton, and is open to the same objections as the other explosives of this family. It has been used with success in Sweden, for torpedoes exploded in contact with a ship's bottom. All these materials are unpleasant to deal with, their questionable advantages are more than counterbalanced by the risk attending their employment, and the uncertainty of their action. Picrate of potash has lately been used by the French for torpedoes, but the recent fearful explosion in Paris shows that it cannot always be trusted. Of this substance we have no practical experience. On the whole, gun-cotton satisfies all our requirements, when we desire anything more powerful than powder, and its safety and tractability render it peculiarly valuable for employment in rough descriptions of work, where the utmost precautions cannot always be taken. Other compounds may be found to give good results in the laboratory, where every refinement of apparatus and manipulation is available; but it may be broadly laid down that in an explosive for practical purposes, the essentials are simplicity, safety, and trustworthiness.

To sum up the substance given in these pages, we see the application of explosive compounds to the purposes of submarine mining, advancing step by step, from rude appliances and wild conjectures, to scientific machinery, and rules based upon the laws of nature. We see the monster charges, at first considered essential, fired with their clumsy powder-hose, or bits of hot metal dropped down a tube, gradually giving way to more rational quantities, and Volta's pile introduced as the igniting agent. Then, with the progress of electrical science, the discovery of the conducting power of water, enabling one wire to be used instead of two. Next the employment of electricity of high tension, generated by a small portable instrument, superseding the objectionable battery with its poisonous acids and fragile cells; and, lastly, we see the detonating fuze developing the gigantic power of the hitherto unmanageable and eccentric gun-cotton.

On the general points to be attended to in conducting operations of this description, our present experience may be stated as follows:—

The first thing to be done is invariably to make a thorough examination of the nature and state of the obstruction.

Where great resistance is anticipated, gun-cotton will prove especially serviceable, and generally so in most cases, except perhaps of a ship much shaken, or weak in construction, which would be better destroyed by gunpowder in small charges.

The charges should be regulated according to the depth. A safe rule to follow is to use $\frac{1}{4}$ of the square of the depth in feet for the charge in pounds. This applies to gunpowder; for example, at a depth of 30 feet, use 225 lbs. For gun-cotton, $\frac{1}{4}$ of the weight so found is sufficient.

Charges should be placed inside a ship, unless the operation is likely to be attended with risk to the divers, or she is much filled with cargo or mud, because ships are built to resist pressure from the outside, and yield readily to a force from within.

To calculate the quantity of powder required to destroy a wreck, allow 20 lbs. per foot length of the vessel; thus, for a ship 100 feet long allow 2,000 lbs.; this is more than enough in most cases.

Under favourable circumstances, and where military labour is available, the cost may be roughly estimated at £1 per foot; that is £100 for a ship 100 feet long. This is only the cost of blowing up, not of removal.

A wooden ship requires as much explosive material as an iron one, but the subsequent removal is less expensive.

Demolitions should not, unless it is imperatively necessary, be undertaken in winter, when short days and bad weather involve loss of time and delay, and workmen are subjected to hardship and exposure.

The base of operations should be on the spot, so that the men can be ready to work at all times, according to the state of the tide; a commodious vessel to house the working party should be provided, also a lighter with gear for lifting heavy weights, and a large boat for the divers.

Casks can be used for cases up to a depth of three fathoms, after which they require strengthening, or, what is preferable, iron cases should be substituted. A double protection to the charge should invariably be provided, the second being either of tin, india-rubber, or water-proof canvas.

Simultaneous explosions of several charges should not be attempted, unless the electric cable is very good, and there is no chance of its getting broken or injured between the various charges. If these conditions can be ensured, they can be used with great effect.

A charge should not be fired while any portion of the wreck in its vicinity remains out of water, as fragments are liable to fly to great distances, but a very slight covering of water is sufficient to prevent this taking place.

In concluding this paper I must observe with regret, that I have left unsaid many things in connection with the subject, which are both interesting and important, especially as regards the application of electricity to the explosion of charges; but I have found it a task of sufficient difficulty to condense information on the main points to be considered, into a reasonable compass, without touching upon collateral subjects. So many different studies are involved in this question, that I have several times found myself in the dilemma of either passing over some point unexplained, or wandering away from my subject to get at first principles. My endeavour has been, not to produce an entertaining essay, but to give as much practical information as possible in a small space, for which purpose the brief accounts of former demolitions, with their numerous failures, are instructive; and if I have to any extent succeeded in so doing, though at the expense of interest, my object will have been gained.

Commander W. Dawson, R.N.: I am sure Mr. Jekyll's paper has been most interesting. The only fault I have to find with him is, that he stuck so closely to his text. I hoped that he would have gone a little out of the way, and given us some of that great fund of information which they have at Chatham with reference to the laws which govern submarine explosions in general. I came into this room hoping that the authorities had removed the bar which has been put upon Officers of the two Services, getting the exact information which exists with reference to the very important subjects which Mr. Jekyll has brought before us, and upon some collateral points. For I need not say that the explosion of gunpowder and gun-cotton under water has reference not only to the peaceful subject to which he has called our attention, but also to very hostile purposes, for which there can be no doubt that in future wars it will prove a very powerful weapon. I am not going to deviate so far as to go into that particular subject, but I cannot let the occasion pass, without saying that in my humble opinion it is a great mistake for the Royal Engineers and the gunners of the "Excellent" to be employed in accumulating a large amount of important information on submarine explosions, and that that information should be stored up on the shelves of the War Office or Admiralty, and not be communicated to the Officers of the two Services. It is a very important point that we should have this exact information with reference to submarine explosions, otherwise Officers may be led away by the false statements published.

I mean to confine the remarks that I have to make to this one part of the subject that has been brought before us; because the subject is a very large one, and there are gentlemen in this room so thoroughly acquainted with the best modes of submarine ignition, and also with the explosive compounds which are to be enclosed in the cases, that it would be the height of presumption on my part to offer any remarks upon those two parts of the subject, upon which they will doubtless speak. The necessity of our having exact information is shown by the fact that the Officers of both Services are limited for their information to such garbled statements as come from foreign countries of experiments that are said to have been made there. And, unhappily, some of those garbled statements have got into the very best type, and on to the very best paper, and in the very best binding, which gives them an appearance of authority to which they have no right, and, consequently, some of my brother Officers who have not had the opportunity of studying this subject so much as others in the room, are liable to be led away into crediting the wildest statements in reference to the explosion of gunpowder under water. I allude now to a book which was published last year by Lieutenant-Colonel Von Scheliha, late a Confederate Officer, whom one might expect to give a correct statement of how the Confederate States endeavoured to blow up 25 of the Federal ships, and injure nine others; because, if we did possess exact information with reference to that, we should learn a great deal about submarine explosions. What are the statements which I find in Von Scheliha's book? In the first place, he gives us simply a reprint of the Federal despatches, and of some old pamphlets published in this country years ago. But in one chapter he gives us very exact details of submarine explosive experiments; so exact that one is tempted to believe that those experiments must really have been carried out by somebody, somewhere, and at some given time. But he does not tell us who carried out those experiments, when they were carried out, or where they were carried out. I find at page 282 of his book that: "A torpedo containing a "charge of 400 lbs. produced at a depth of 12 feet, and at a distance of two feet "from the vessel, no effect on the side of the vessel." Mr. Jekyll could tell us that that is an absurdity, that 400 lbs. of powder so immersed would be effective upon a substantial ship if afloat, at a horizontal distance of 14 or 15 feet. On the same page Von Scheliha tells us that, "a thousand pounds of powder enclosed in a strong wine cask produced, at a depth of 18 feet, and a distance of *four* feet from the vessel, hardly any effect whatever!!!" Now, we know very well that a thousand pounds of powder so immersed would be effective against a strong ship afloat at a horizontal distance of about 20 feet. Turning to another page of the book, I find he makes 150 lbs. of powder, exploded with 15 feet immersion, effective in breaking iron rods at a distance of 27½ feet. How he reconciles those two statements I do not know. Neither of them is correct. It would have been nearer the truth if he had stated

that this 150 lbs. of powder would produce its principal destructive effect at 10 or 11 feet. At page 283, Von Scheliha further states that at a distance of *four* feet *below* the bottom of the vessel, 400 lbs. of powder produced a *doubtful* effect. I need hardly say that the explosion of such a charge so placed would send the bottom of the strongest ship right through all the decks into the air. Then comes a general statement, equally fallacious, at page 285, that the effect of torpedoes placed close to, or on the bottom of the channel, seems to spread more in a horizontal than in a vertical direction. Mr. Jekyll has shown us that the relation between the horizontal powers of an explosion and its vertical effect is dependent upon the depth of immersion and the amount of the charge; and that in order to prevent an excess of vertical effect, he found it necessary to use comparatively small charges proportioned to the depth of water. I merely mention this to show the advantage which we should obtain if other branches of the profession could only get at the exact information which the Royal Engineers possess.

There are two things to be considered in placing a submarine charge: first, its depth of immersion; secondly, its horizontal distance from the object. With reference to the work which Mr. Jekyll has in hand, of course, the question of distance does not come in, because the object being fixed on the ground, the charge can be placed in contact with it; therefore, the only question to be considered is, the depth of water. Moreover, the destruction of a wreck full of water or sand would necessitate the employment of a larger charge than the destruction of a ship afloat, the charge being similarly applied, so that it is difficult to reason from the conclusions arrived at on one subject, to that which ought to obtain on the other. I am afraid I should be travelling wide of the subject if I said anything further except upon the particular point to which Mr. Jekyll has confined himself so well. But I cannot sit down without expressing my admiration of the zeal, ability, and patience which have characterised the operations of the Royal Engineers in carrying out a most difficult investigation, and conducting a series of most painstaking experiments for the purpose of arriving at those very facts which Mr. Jekyll has communicated to us in a very few paragraphs. For years they have been engaged in submarine explosive operations, and it is hardly to the advantage of the other branches of the public service that the result of these experiments should be withheld from them. There is, however, one point I wish to speak to before I sit down. The explosive experiments which have been conducted by the Royal Engineers, important as they have been, and great as have been the truths they have brought out with reference to the laws which govern such explosions, have been made with comparatively small charges. Those experiments should be verified by much larger explosions. From time to time, opportunity should be taken, when vessels are being broken up, and on other similar occasions in which larger explosions might be made, of exploding different amounts of powder or gun-cotton, arranged at fixed distances, in order to ascertain whether the law which governs the effects of small charges, governs also the results of larger charges. I suppose when we apply these charges of powder for hostile purposes, we shall apply charges of a thousand pounds of powder, or the equivalent in gun-cotton, for stationary purposes, and when we employ them for locomotive purposes we should not recommend any charge less than 150 lbs. We should know exactly what the effect of that 150 lbs. will be upon our own vessel if we do not hold it at a safe distance, and also how near we ought to bring it to an enemy's vessel in order to destroy her. Upon those points we have already a vast amount of theory and some little practical information, but we want much more real experience with the actual weapon, in the complete form, in which it would be actually employed on service.

Lieutenant JEKYLL: With reference to the question of torpedoes, I have had quite enough to do to talk about the subject which I have in hand, the destruction of vessels under water, without touching upon torpedoes. It is a very large field; it is impossible to condense into the space of an hour any information respecting it. With reference to the present state of the subject that Captain Dawson has been speaking to, we have a great mass of experiments, and we have a still greater mass of theory; but we have not a very large amount of practical information to go upon.

And the authorities at present appear to take so little interest in the subject that it is not likely we shall get much more.

Commander DAWSON: Might I ask one more question, with reference to the effective distance at which gun-cotton may be made use of, when exploded by detonating fuzes, if it is not a secret?

Lieutenant JEKYLL: I can hardly answer that question off hand.

Commander DAWSON: We now know pretty well the horizontal distance at which given charges of gunpowder or gun-cotton, exploded in the old way, will be effective when exploded against a ship. For instance, we know that 100 lbs. of gunpowder, or its equivalent in gun-cotton, if it is immersed to a depth of 10 or 15 feet, will be effective at a horizontal distance of 9 or 10 feet; we know that 1,000 lbs. of powder, if it be immersed at any depth below 10 fathoms, will be effective at a horizontal distance of 20 feet. The question I want now to put is with reference to this new mode of exploding gun-cotton by detonating fuzes, whether the horizontal distance at which the immersed charge will be effective is increased by the mode of ignition, and how much it is increased in relation to that of gunpowder?

Lieutenant JEKYLL: As far as our experiments have gone at present, we are fully satisfied that a charge of gun-cutton, one-fourth the weight of a given charge of gunpowder, will produce equal results at the same distance; using the detonating fuze, of course, which is always used with charges of gun-cotton. But our experiments as yet have been so few that we have not determined the exact distance yet.

Commander DAWSON: How do you reconcile that with the statement that an explosion of gun-cotton killed so many fish a long distance off?

Lieutenant JEKYLL: That is from the peculiar nature of the explosion: probably from the shock being transmitted through the water.

The CHAIRMAN: If no other gentleman has any question to ask, I am sure this meeting will agree with me that we have had a highly interesting paper from Mr. Jekyll. I beg to return him, in the name of this meeting, our best thanks for his communication.

LECTURE.

Friday, June 4, 1869.

COLONEL PHILIP J. YORKE, F.R.S., Vice-President, in the Chair.

THE APPLICATION OF PHOTOGRAPHY TO MILITARY PURPOSES.

By H. BADEN PRITCHARD, of the General Photographic Establishment of the War Department.

THE applications of photography to warlike purposes in this country are numerous and various. At the Ordnance Survey Office, Southampton; the Engineer Establishment, Chatham; the Barrack Survey Department; at most of the Royal Engineer stations abroad; as likewise at the General Photographic Establishment of the War Department at home, the art is more or less employed in the prosecution of work undertaken by those establishments. In connexion with the production of surveys, the engraving of maps, the copying of designs, the registration of service patterns, the recording of experimental results, the instruction of troops, the controlling of work performed, and in other directions too numerous to mention, photography is extensively employed to do yeoman's service; the faithful accuracy with which the art fulfills its functions, causing its aid to be eagerly sought for in any way where it can be made available. Not only, however, does the employment of the camera recommend itself on the score of fidelity, but likewise by reason of the very inexpensive nature of the results furnished, and the degree of facility with which they are obtained. From the fact that they are invariably absolute copies of the originals, reproductions obtained by means of photography must always be endowed with a certain value, while in many cases, where it would have been impossible to have secured pictures by any other means, the results of the camera are simply priceless.

The first time that photography was used in connection with military matters was during the Crimean war. Lord Panmure, then Secretary of State for War, conceived the idea of securing some photographic records of the campaign, which would afford reliable information on various points; he accordingly consulted Mr. J. Mayall, the well-known London photographer, on the practicability of carrying out his project, and requested that gentleman to undertake the instruction of

two Officers detailed for duty as photographers. These Officers—Ensigns Brandon and Dawson—were accordingly instructed by Mr. Mayall in the wet and dry collodion processes, as likewise in the albumen process, a method which proved especially suitable for manipulating in hot weather. Their equipment was superintended by Captain Foulkes, and the results they obtained were on the whole very satisfactory, some of the large views taken, being especially interesting. The series of pictures produced, or at any rate a large proportion of them, are, I believe, still stored up at the War Office, although I have reason to fear they will be found to have faded considerably; for it must be borne in mind that at the time these photographs were produced (1855–56) the art was still in its infancy, and many of the manipulations pursued, were necessarily of an experimental or imperfect nature. Besides the Crimean pictures taken by these Officers, some very important views were secured by Messrs. Fenton and Robertson, many of whose results are still in a state of good preservation.

Since that period, the art-science has progressed to a wonderful degree, so much so, indeed, that we cannot but anticipate its speedy and complete perfection. In the same ratio as the process has improved, its applications have increased and become more wide-spread, and the necessity for a diffused acquaintance with the subject has been so fully appreciated by the Authorities of the War Department, that a school of instruction has been formed for the special purpose of imparting to classes of young soldiers a knowledge of the details and manipulations of the process. This school, which forms portion of the Royal Engineer Establishment at Chatham, and is now under the direction of Captain Stotherd, R.E., has during the period of its existence been of considerable benefit to the Service. During the recent Abyssinian campaign, a staff of photographers, instructed and equipped from this establishment, was attached to the Quartermaster-General's Department, and did good service in copying maps and sketches of the route, and in taking pictures of those objects and points of interest, of which a record was considered desirable. The operators were seven in number, Serjeant John Harrold, R.E., being the chief photographer of the party, and the results of their labours, conducted as the latter were, under circumstances of considerable difficulty, speak much for the ability and skill of the Non-Commissioned Officer in charge.

Passing from photography in the Field, to which I shall presently return, I come to the applications of the process made by the non-combatant portion of the Service. One of the most important uses to which the process is put, in the British War Department is, without doubt, as an aid in the copying of maps, plans, designs, rare M.S., &c., as practised at the Ordnance Survey Office, Southampton. In this establishment the process of photozincography, the invention of Colonel Sir H. James, R.E., has been carefully elaborated, and employed with such marked success, under the direction of that Officer, that the Governments of France, Austria, Belgium, Holland, and America have adopted the art, or some modification of it, for carrying on work of a similar nature. Indeed to so great an extent has the process been taken

up, that Sir Henry James's establishment may be regarded, in many respects, as a model upon which the Foreign Military Survey Departments have been constructed. The principal work performed by means of photozincography at Southampton, is the production of special maps for warlike and other purposes, in those cases where rapidity of execution is necessary, and when the expense of tracing them by the ordinary engraving method cannot be incurred. Besides its application in this direction, Sir H. James's process has done valuable service in furnishing reproductions of unique M.S., such as the great and little Domesday Books, the national M.S. of England and Scotland, and other important works, all of which are necessarily reproduced with perfect truth and accuracy, and without the necessity for tampering in any way with the originals.

Photography is also used by the Ordnance Survey in obtaining pictures of objects of national importance; and at the present time the surveying party engaged in the Peninsular of Sinai have attached to them a photographer from Southampton, who, according to latest accounts, has secured more than 150 important views of the country. The Royal Engineers sent out to survey Jerusalem also brought home with them upwards of 100 views of interest.

At the General Photographic Establishment, a branch of the Chemical Department at Woolwich, under the direction of Professor Abel, F.R.S., the camera is employed in very many ways. All experimental structures, whether in the shape of shields, guns, small arms, waggons, slides, rockets, &c., are photographed, and pictures thereof recorded; the results of firing experimentally against iron plates of different thicknesses are reproduced and preserved; instructional pictures shewing the methods of working guns of different descriptions, and the positions taken up by individual gunners on the issue of the various orders, are taken; photographs exhibiting the regulation mode of wearing accoutrements, the precise manner in which the harness of horses is adjusted, the method of packing waggons, and fitting service-saddles, the mode in which military tents and equipage are set up, as well as the preparation of pictures of newly adopted stores and implements, are among the duties fulfilled at the department. Prints from the negatives thus obtained are issued to various branches of the Army, both in this country and in India, so that any information which it may be necessary to give to subordinate departments is by this means diffused in an intelligible and rapid manner throughout the whole of Her Majesty's dominions. The sizes of the pictures issued from Woolwich vary from $10'' \times 8''$ to $15'' \times 12''$, and the annual issue of prints fluctuates from 18,000 to 25,000.

While on the subject of photography at Woolwich, I would mention one direction, in which its aid might possibly be invoked to good purpose at that and other manufacturing stations; in respect, namely, to rendering unnecessary, in many instances, the construction and preservation of costly patterns. In the manufacture of certain articles of equipment, it is doubtless necessary that a perfect and carefully-finished specimen should be at hand, serving both to guide and control the work; but where munitions of war differ from each

other only in size or in matters of detail, and where the nature of materials used in their construction need not actually be exhibited, lithographed plans, together with photographs taken to scale from various points of view, would afford ample information for their manufacture. Thus, of all articles of *matériel* adopted into the Service, one specimen of each type might be preserved as a pattern of a certain class, and this pattern, together with descriptive information and appropriate sketches, would suffice for the construction of all articles on the same principle, but of modified form. In the majority of cases, three photographs would be sufficient to accompany the lithograph drawings; they would be taken to scale, and in such a manner as to show detail, without distortion of the picture. To facilitate the operation of photographing in an instance of this kind, it would be advisable to colour roughly those portions of the object which it is desired more accurately to depict, or to attach to them descriptive labels to be reproduced by the camera. It is scarcely necessary to state, that the cost of producing pictures of this description would be very small, and, inasmuch as lithograph plans of all service articles are already in existence, the adoption of this method would be a measure of undoubted economy. Moreover, copies of these plans might be made at a trifling cost for deposition at the War Office and Horse Guards, by which means those departments would be kept well informed upon the subject of service patterns.

Modifications of Sir H. James's photozincography are likewise used at Woolwich, at Chatham, and, as previously stated, abroad, but as it is my intention on the present occasion to treat more especially of the employment of photography proper by the Army in the Field, I will defer my remarks in regard to the extent to which the art is employed in foreign War Departments, and proceed at once to describe in what way the camera has been, and may be, employed in connection with campaign service.

The avowed purpose for which photography has been hitherto used in the Field, is as a means of reducing and copying plans and maps; the taking of pictures of important localities and interesting objects, has occasionally occupied, it is true, a portion of the military photographer's labours, but the production of such results have been always considered as partaking of a private or semi-official character.

In the capacity of multiplier and printer of maps, the aid of the photographer is very welcome. During the progress of troops through strange lands, it is of the last importance that the Commander-in-Chief should possess a perfect knowledge of the country by which he is surrounded; not only is an acquaintance with the position of the roads, rivers, and mountain ranges, such as shown on ordinary maps, requisite, but information in respect to minor details, as for instance, the nature of the ground, the whereabouts of timber and hedgerows, paths, and other land marks, is likewise needed. To prepare plans of this description on a large scale, Staff Officers are detached on *reconnaissance* expeditions, and the information thus collected is at once committed to paper and forwarded to the Quartermaster-General's department. Here we may see at once the important use to which

the camera may be put. The plans are necessarily drawn to scale, but it is by no means imperative that all sketches should be made of the same relative dimensions, for in reproducing them in the camera, the originals may be easily enlarged or reduced to any standard measurement. If a large issue of copies is required immediately, several negatives are at once taken, and these, consisting simply of opaque glass with transparent lines, are easily and rapidly printed. As an instance of the expedition with which work of this kind is conducted, I may mention that during the Abyssinian campaign, as many as thirty copies were sometimes prepared and distributed to brigadiers and others within four-and-twenty hours of the original plan being sketched. The maps are printed upon paper and mounted on linen, so as to render them stout and durable; but it will be a question for consideration whether it is not better to print direct upon the fabric. By saturating linen, cambric, or silk with albumen, or even simply impregnating it with a solution of salt, a very suitable material may be produced which can be folded up and packed away without risk of damage, and is yet sufficiently stiff for purposes of a field map. No difficulty would be experienced in preparing the fabric for photographic purposes, and in this state it may be manipulated with as much facility as paper. Moreover, by its adoption, the time-taking-operation of mounting would be dispensed with, and the prints being upon a more permeable material than paper, would require a less amount of washing, an operation of very great importance in photography.

I have said that the taking of landscape and other pictures by photographers in the Field has not been considered, up to the present time, as strictly within their official duties, and photographs of this description have, therefore, hitherto been very sparingly produced. This is much to be regretted, as it certainly seems unwise when the Staff has been provided with all the appliances ready at hand, that the same should not be employed, at the discretion of the Commander-in-Chief, in obtaining records of such objects as are likely to prove of value and interest. As an illustration that pictures of this kind are frequently of great worth, we may instance the series of views of Abyssinian scenery taken during the recent campaign, in respect to which the only fault to be found is, that there are so few of them. These photographs are at present of the utmost value, and those of Magdala, representing a stronghold as it has existed probably for centuries, and which exists no longer, are altogether irreplaceable. And yet these pictures would never have been obtained if the camera had been devoted exclusively to the purposes for which it was designed; we owe them entirely to General Napier or his Staff, who, on individual authority, gave orders for their preparation from time to time. In the same way a few mementoes were obtained of the Indian mutiny and Chinese war of 1860; but unfortunately in these cases, the pictures preserved of the campaigns are even fewer than those of Abyssinia.

Besides, however, the question of obtaining pictures of points of interest for subsequent preservation and record, landscape views taken judiciously, might be made to render considerable aid to an Army in

the Field. In the first place, by employing a modification of the ordinary camera, it is possible to use the same as a surveying instrument and plane-table in the manner recommended by Captain Jouart, and adopted to some extent by the French War Department. Again, another mode of utilizing the lens would be as a reconnoitrer and judger of distance; by employing an instrument possessing a long focus (the body of the camera being in the form of a telescope so as to be capable of fitting into small compass), a very serviceable view might be taken of a fort, embrasure, or fortified locality, at a distance exceeding 1,500 yards, and out of range of small arms. A clearly-defined picture, produced in this manner, is capable of being enlarged to the extent of five or ten diameters, and thus a sketch of useful dimensions may be secured of an enemy's position without much risk of danger. It would merely be necessary in a case of this kind to obtain the picture in the first instance perfectly distinct and sharply in focus, the camera being directed at the object when the sun's rays impinge upon the latter at an angle of about 45° (the most suitable angle for landscape photography), so that all details are sufficiently illuminated. To demonstrate what may be done in this matter, and at what a distance it is possible to operate successfully, I may mention that I have been able to photograph a building situated two miles from the camera, and subsequently to obtain an enlarged picture thereof, which, had it been taken direct, would have necessitated the approach of the camera to within one-eighth of the above-named distance. The camera may, as I have said, also be used in this way as a theodolite, and the distance or range between the reconnoitring party and the enemy's position accurately and rapidly determined, supposing the actual dimensions of the enemy's fort or entrenchment to be known. Thus, if the object to be photographed is 50 yards long, and the image depicted upon the focussing-glass measures one inch in length, it is easy to calculate the exact distance which intervenes between the object and the camera, knowing as we do the focal length of our lens; if the latter amounts to 25 inches, it is clear that the object depicted in the camera is precisely 1,250 yards distant. In making these calculations, the image must always be sharply focussed and accurately measured by means of a glass rule, upon which a finely-divided scale is marked.

Another use to which the camera may be put in the Field is in the production of landscape pictures to illustrate the ground plans or sketches of routes circulated throughout the Army. One or more stereoscopic views, showing the undulations of the country, the nature and description of the land, whether of a cultivated or rugged character, whether wooded or agricultural, would greatly enhance the value of these plans, and would convey at once to Commanding Officers precise information respecting the country through which troops will have to march. If stereoscopic views were considered of too large a size, smaller pictures might be taken and subsequently enlarged; but in the case of single photographs only being appended to the maps, they should invariably be examined by means of a magnifying glass, as *relief* is thus imparted to the picture, and its details more faithfully portrayed and understood. The time and trouble involved in obtain-

ing these pictures would be very trifling, and no especial knowledge in manipulating the process would be required for the purpose. An Officer attached to the reconnoitring party could easily carry the two packages necessary for the purpose, which might vary in size from three inches cube upwards, according to the dimensions of the view required. One of these packages would be the camera, and the other a couple of carriers, or plate-box, similar to that fitted to Edward's miniature apparatus. The camera might be provided with a lens, which should always be in focus, or, inasmuch as pictures would generally be taken at some considerable distance, an ordinary lens might be used, the focus of which has been adjusted to an object distant one hundred times the focal length of the instrument; for it has been found that a lens thus focussed, yields a tolerably clear definition of any objects beyond the distance mentioned. The camera, therefore, has merely to be set down in the direction in which the view is to be taken, a glance being all that is necessary to ascertain that the picture required is that depicted upon the screen; the case containing the dry prepared plates (of which more anon) is slipped into the camera, the glass exposed for a given period, according to circumstances, and then returned to its former position. This is all that need be done, and it is no exaggeration to say, that any Officer would require but a few minutes' instruction to be able to take three or four pictures in this manner within a quarter of an hour. On returning to camp, the plates are handed over to the photographic staff, with an intimation of the length of time they were exposed to light, and the negatives would then be developed, and printed in the ordinary manner.

These field pictures should, as a rule, be taken of small size, not larger, for instance, than can be obtained with an ordinary stereo-camera, an instrument of very considerable value for out-door work. A large camera is, of course, a necessary adjunct for field purposes, as it is only by means of an apparatus of notable dimensions that plans can be reproduced; but, at the same time, the staff should be invariably provided with a small camera, the advantages of which are as important as they are numerous; it may be more easily worked, and with much less risk of failure; its action is always rapid, and often *instantaneous*, a quality of the last importance; it involves less expense, less bulky apparatus, and less skill in manipulation; and, furthermore, the pictures produced by it may subsequently be enlarged to any desirable size. Indeed, in a hot, sunny climate, such as is encountered in the tropics, the instantaneous action of these small cameras is frequently a source of inconvenience, owing to the extreme sensitiveness of the collodion; the rays of light entering the camera may, of course, be diminished by employing diaphragms with small apertures in front of the lens to cut off the light; but inasmuch as a photograph becomes distorted and useless for enlarging, if the opening of the diaphragm is less than one-fortieth the focal length of the lens, the only course for the photographer to pursue in such cases is to modify the sensitiveness of his collodion. This may be done by diminishing the amount of sensitizing salts, as the rapidity with which a

collodion acts is governed mainly by the quantity of these salts contained in it; and if required for landscape work, where much detail and half tone is necessary, the proportion of bromide to iodide should be large. Five equivalents of bromide to one of iodide would probably be a good proportion to use, provided the dipping-bath employed, were so prepared as to prevent the fogging of the negative. In compounding collodions for hot climates, it would, moreover, be well to employ a maximum quantity of alcohol, and to sensitize with those salts only which exert a liquefying action upon the material, as, for instance, the iodide and bromide of ammonium. These are, however, details the value of which, practical investigation can alone determine.

As an example of the manner in which photographic sketches attached to a military plan will aid in conveying a more perfect and truthful idea of the country represented, we will suppose lying before us a ground sketch of a fortified position, or entrenched camp. The plan might be required by the Officer Commanding, either previously to an attack, or to accompany and illustrate a report made to the authorities at home after the stronghold has been wrested from the enemy. A ground plan is sketched out in the usual way, with the roads, villages, rivers, and woods lying around, carefully marked, and an outline of the fort depicted as accurately as possible; around this plan are then placed photographs of the more important points of the fortress, the direction in which these pictures have been taken being shown by dotted lines marked upon the ground plan. These photographs may, if necessary, be taken at a considerable distance from the object, and then enlarged, one picture being a general view, showing surrounding country, another being a representation of the principal embrasures, a third showing the ditch or palisade surrounding, &c. Thus, constructed, a plan could not but fail to show immediately the position of affairs, and the Officer commanding, or authorities at home, would rest assured as to the accuracy of the representation, and be quite certain that the same has not been exaggerated or overdrawn.

Indeed, this method of making reports through the medium of photography is by no means a novel idea, but has been acted upon continually by several large firms of contractors. Thus, Messrs. Brassey and Betts, whilst recently constructing a railway in South America, trusted almost implicitly to photography as a tell-tale, or registry of the progress of the work. A photographer was stationed by them on the site of the railway, and when the periodical reports were made to the contractors in London, announcing the completion of certain portions of the line, and requesting the money advances agreed upon, these documents were invariably accompanied by a series of photographs supporting the statements as to the forward condition of the undertaking. In Russia, and other countries on the Continent, like arrangements have been made, thus obviating the necessity for the contractor's presence in countries where they may be disinclined, or unable, to take up their residence.

Among other miscellaneous services which the camera would fulfil to advantage, there is one connected with Naval matters deserving of mention. It has formed part of a vessel's duty, on more than one

occasion, to pass rapidly in close proximity to an enemy's batteries for the purpose of obtaining a glimpse of the strength thereof. In fulfilling a task of this kind, a small, quick-acting instrument would be of the utmost value in taking a series of instantaneous views, which would record information in the most precise and reliable manner; a finder, or small camera, fixed rigidly to the larger one, would be required to indicate the right time of exposing the plate, an operation which would take place as soon as the image to be secured is depicted upon the focussing screen of the finder. In performing manipulations like these, it would be imperatively necessary to secure a suitable opportunity when the enemy's works are favourably lighted up, and to ascertain by previous experiment that the apparatus and chemicals are in good working order.

In the course of these observations I have pointed out how much may be done in photography in a rough and ready manner, and with but slight experience of the process; but for all that I do not mean to say that a photographer's duties in the field are unbeset with difficulty. On the contrary, it requires considerable experience, and sound theoretical, as well as practical, knowledge on the part of the chief photographer when working for a lengthened period continually in the open air. The mishaps and unforseen dilemmas which encounter the operator at home are by no means few or unimportant, but when the processes, both of obtaining negatives and printing from them, have to be performed without the usual appliances, and recourse had to a variety of makeshifts, misfortunes are apt to arise which require the exercise of considerable skill and patience to overcome. The manipulation of the various chemicals according to the heat of the climate and intensity of the light, the detection and prevention of failures in the process, the power of devising suitable improvisations in cases of need, must be well understood to ensure successful results in matters of detail; while it is absolutely necessary for the production of a good negative that the photographer should enjoy the utmost freedom in his mode of operating, and be allowed to perform his duty in his own way, in order that due attention may be paid to the manner in which the object is illuminated, to the position of the camera, to the time of manipulating, and to various other points of a technical nature. That a good photograph is no mere mechanical result, but dependent upon the skill and judgment of the operator, is at once apparent from a glance at the beautiful art productions of Mr. H. P. Robinson and Mr. Rejlander.

For these reasons, therefore, it is very desirable that the head of the photographic staff in the Field should always be a responsible person and likewise a Commissioned Officer, to whose judgment and discretion the manner of performing the various photographic duties would be left; thus the possibility would be avoided of pictures being attempted against all technical rules and theoretical principles, and worthless results being obtained in the endeavours of the operators to execute impossible orders given them from time to time by Staff Officers unacquainted with the exigencies of the art.

The important advantages accruing from the use of dry-plate-

photography in the field, are very obvious. The large, cumbersome, dark tent, the stock of chemicals and utensils, the apparatus required for the preparation and development of the negative, are all unnecessary, the camera, stand. and plate-box, or two or three dark slides, being all that is required. Besides the saving of trouble, there is, moreover, the saving of time to be considered, for with the dry process it is requisite merely to expose and withdraw the plate from the camera, postponing all other operations until a more convenient opportunity; it may be some hours or even days afterwards. With a wet plate however, there is the process of coating the plate, immersing it in the silver bath, and subsequently developing the image, operations which consume a notable amount of time, and which cannot be hurried over without greatly jeopardising the value of the result.

During the past twelve months I have studied with some care the question of dry plates, their mode of preparation, keeping qualities, and adaptability to employment in the Field, and for military purposes in general. The preparation of preserved sensitive plates was due in the first instance to Mr. John Spiller, F.C.S., recently in charge of the General Photographic Establishment, who in conjunction with Mr. W. Crookes, F.R.S., prepared and experimented with them as early as the year 1854. Since that period, considerable improvement has been made in their preparation, and at the present time dry plates may be obtained possessing the same degree of sensitiveness as a plate taken direct from the silver-bath. The manner in which plates of this kind are produced is very simple. A sheet of glass is coated with collodion and dipped in the silver-bath in the ordinary manner to render it sensitive; after being thoroughly washed, a preservative solution is poured over the surface, and when it has again been rinsed and dried, the operation is finished. The degree of sensitiveness possessed by a dry plate, and the period of time during which it retains this sensitiveness, depends principally upon the nature of the preservative used, and also upon the care exercised in preparing the plates. Substances of almost every description have been used as preservatives—tannin, honey, coffee, tea, gum, albumen, morphine, syrup, &c., but my experience leads me to the conclusion that the best and simplest dry-plate processes are the gum-method of Mr. Manners Gordon, and that of coffee proposed by an Officer of the Italian Army, Colonel Baratti. The gum-process is preferable when sensitiveness is the main point to be observed, the coffee, when it is likely that a long period of time may elapse before employment of the plates. I have known coffee-plates to retain their sensitiveness after being stored away for a period of fifteen months; at the same time it is never well to employ dry plates more than a month old in any case where a reliable and perfect result is desired. As a proof that dry plate photography is already an established fact, I may mention that one of our best landscape photographers, Mr. William England, recently obtained a series of 400 dry-plate pictures during a tour on the Rhine. They were prepared with albumen, and the results are fully equal to those obtained with wet plates.

I now proceed to a point of considerable importance, and one which

has caused the advocates of photography no little anxiety; I allude to the questionable permanence, or rather instability, of ordinary photographs. Many of the prints we possess, taken ten or fifteen years ago, show unmistakeable signs of fading, and even those which are still whole and free from blemish will, in all probability, suffer perceptibly after a few score of years. This liability of albuminized prints to fade, and even to disappear altogether after a lapse of time, is one of the most serious defects connected with the printing process at present in ordinary use. Look at any collection, portfolio, or album of prints that have been in existence for some years, and there will be found many which, if they do not show distinct signs of disappearing, have at any rate lost to a marked degree their pristine freshness and brilliancy. This tendency of photographs to deteriorate is to a great extent inherent to the mode of their preparation, and cannot always be guarded against. The surface on which the prints are produced, consists of a sheet of fine white paper, coated with a film of albumen, to which a suitable chloride has been added in minute proportion. By floating upon a solution of nitrate of silver, the chloride in the albumen becomes transformed into chloride of silver, and gives up the element with which it was previously combined. The chloride of silver now present in the albumen film renders the latter sensitive to light and capable of being printed upon under a negative, the result thus obtained being toned down to an agreeable colour by means of a suitable bath containing a compound of gold in solution, and finally fixed in hyposulphite of soda, and well washed. The operation of washing, to free the print from all traces of hyposulphite of soda, is one of the most important connected with the printing process, as the presence of the slightest quantity of sulphur in the finished print must eventually bring about a reaction upon the silver, and the destruction of the picture. It is by reason of imperfect washing that so many of our ordinary photographs become discoloured and faded, but at the same time even the most careful treatment in this respect will occasionally fail to remove the destroying agent, which remains locked up in the albuminous film, defying all efforts made to remove it. The sulphur contained in the atmosphere, likewise exerts an injurious influence upon silver prints, and on this account it is customary to coat valuable pictures with a film of impermeable varnish, to preserve them as much as possible from atmospheric influence.

It is because of the instability of silver prints that attention has been of late years directed to the discovery of a process by which pictures of undoubted permanence may be obtained. Many methods have, from time to time, been proposed, and at the present moment there exist two sound practical processes by which the desired object is secured. Both these inventions, which are now competing for public favour, are due to investigators in this country, the first the carbon-process, eminating from Mr. J. W. Swan, of Newcastle, and the second the Woodbury photo-relief process, the invention of Mr. Walter Woodbury.

Both processes are based upon the effect which light has upon the bichromates of ammonium and potash when in contact with an

organic substance. It is well known that if upon a sheet of white paper coated with a solution of bichromate of potash there is laid an opaque design (such as a fern leaf), and the surface exposed to light, the sun's rays will act upon the uncovered portions of the sensitive film and convert the same into an insoluble chromic compound; so that if the sheet is subsequently washed in water, that portion of the surface protected from light is washed away (being still soluble), while the other parts remain unaltered and attached to the paper, forming a representation of the object previously placed thereon. This action of the sun upon the bichromates is the keystone of the two processes, which differ, however, from one another in this essential particular, that whereas in the carbon-process light is necessary in the production of every single print, in the Woodbury type its action is only required in making the first matrix or mould from which several hundreds, or even thousands, of impressions may be obtained.

The carbon or autotype process has lately been much simplified, and may be briefly described as follows:—A finely-ground pigment of any desired tint is mixed with a certain proportion of gelatine; the two substances are well incorporated and applied to the surface of fine paper, which is then termed carbon tissue. This tissue is floated upon a bath of bichromate solution, which impregnates it, and so renders it sensitive; after exposure to light under a negative for a sufficient period, the print is soaked in water and placed face downwards upon a sheet of glass or other impermeable surface, to which it becomes firmly attached owing to the suction of the gelatine when swollen with moisture. Immersion in warm water succeeds, an operation which has the effect of removing the paper backing of the tissue, and of dissolving away that portion of the gelatinous compound unacted upon by the light; gradually all that is soluble disappears, and there then remains attached to the glass an image formed of insoluble pigment. We are, however, looking at the image from the reverse side, or from the back, for in the first instance, it will be remembered, we placed it face downwards upon the glass surface; we must turn it round, therefore, an operation effected by attaching to the image a sheet of thin paper by means of an adhesive material, and when dry tearing the same again from the glass, together with the carbon image. Pictures thus produced are of the most durable kind, especially if subsequently treated with a solution of shellac in ammonia, which converts the gelatine into a species of leather. The beauty and detail possessed by these photographs are quite equal to those qualities exhibited by silver pictures, and carbon prints are moreover much less likely to become stained or injured from rough or careless usage.

In the Woodbury-type-process, the prints are obtained by *mechanical* printing. A stout sheet of gelatine is impregnated with bichromate solution, to render it sensitive to light, and then placed in the sun under a negative. This operation finished, the surface of the gelatine is carefully washed, to remove those portions which are still soluble, and the result is a picture in relief; where the negative was transparent, the rays of light have acted upon the bichromated gelatine and rendered it insoluble, but where the negative was opaque,

the light has had no effect upon the surface, and in these parts the gelatine, being still soluble, is easily washed away. This gelatine matrix is hardened by immersion in alum, and then placed between two plates of type metal, and subjected to considerable pressure; the result is an impression or intaglio in the metal plate, or, as we may call it, an engraved design. From this the printing is thus proceeded with:— A sheet of paper is placed in position, and upon it is poured a little pool of black transparent ink; the engraved plate descends, presses out the superfluous ink, and produces a fac-simile of the original photograph. The shadows in the picture being represented according to their intensity by cavities more or less deep in the metal plate, a thicker or thinner layer of the transparent ink is thus allowed to remain upon the paper in those parts, while, on the other hand, there being no depression in the plate where the high-lights are represented, the ink is forced away from those portions, and the white paper remains uncovered by any colouring matter. The gradation of tone in the picture is therefore obtained by layers of ink of unequal thickness. Thus the Woodbury-process produces prints of great stability, and without the aid of the sun, except in the preliminary production of the gelatine matrix; this latter will serve to furnish a dozen engraved plates, and therefore by one single exposure to light we may obtain thousands of prints.

From this it will be readily conceived that the Woodbury and carbon processes are both essentially practical and worthy of adoption; where a large number of prints are required, say a few hundreds from each negative, the Woodbury process would be more suitable, but where from ten to a hundred copies only are necessary, the carbon process would appear better adapted for employment, as the expense of carrying on the first named process on a small scale would be proportionately great. In the General Photographic Establishment at Woolwich, operations of an experimental nature have been carried on with the carbon-process with some degree of success, and in the course of the present year it is believed that all prints issued from Woolwich will be of an absolutely permanent character.

There is one subject to which I cannot refrain from alluding, before leaving the question of permanent photography, a subject which appears to me of weighty import, although perhaps somewhat out of place in this paper. Proposals have been made from time to time, and among others by a Mr. MacLachlan of Manchester, as far back as 1863, that a national gallery of photographic portraits should be formed of personages distinguished in arms, literature, science, art, &c. These propositions have been combated on the score that photographic productions are themselves unstable; but now that we are possessed of a means of producing permanent pictures in a simple and inexpensive manner, the adoption of a scheme of this kind would involve but little labour and trouble, while the value of such a collection would be incalculable. Engravings and oil paintings always partake of the ideal to a certain extent, and are frequently far from being faithful representations of the great men they purport to depict, whereas in a photograph, we see a true and faithful delineation of the features, exactly as they are

reflected from the original upon the camera screen. If the formation of such a collection be contemplated, either through public or private enterprise, no delay should occur in its establishment, and steps ought at once to be taken to secure the negative-portraits which at present exist of men of note who have already left us, otherwise in our apathy, these valuable mementoes may disappear and become lost to us for ever.

In concluding these remarks I have to point out the extent to which photography is employed in the various foreign War Departments, merely observing that my information in this respect has been collected in most instances from reliable sources.

America.—During the recent American war, the value of photography was well appreciated, although its employment appears to have been merely resorted to for the multiplication of maps and sketches of the enemy's country. For planning campaign raids, expeditions, &c., these photographs were found to be exceedingly useful, so much so indeed, that upwards of 4,000 of them were prepared during the period of the war. Besides the work done at head-quarters, each division of the Army had a photographer attached for performing special duties in case of need. A considerable saving of time was frequently effected by employing the camera in this connection, especially during the period preceding a fight, when sketches were wanted for distribution to different corps and division Commanders. Previously to General Sherman's departure on his decisive expedition, all plans relating to the topography of the proposed route were collected, and upwards of 100 copies of each prepared for distribution throughout the General's command.

At the present time, photography is employed by the American Government at the Army Museum, at the United States' Coast Survey Office, and at the Treasury, but at none of these establishments is the process used in any special manner.

France.—In France, for some time past, much attention has been paid to methods of employing photography in the War Department, and more especially in connection with military surveying. The Chevalier plane-table has been experimented with, with fair success, and further investigations are now being made with it by the Minister of Marine at Toulon. Unfortunately, the inventor of this ingenious instrument has recently died, and it is feared that many important applications and perfections, which he had elaborated, have thus been completely lost. According to M. Chevalier's statement to the Emperor, he professed himself to be able, by means of two photographs taken with the plane-table, firstly to regulate in the most certain manner during the night, the direction of fire and the precise angle at which the electric-light reflectors employed against any point of attack should be adjusted; and, secondly, to regulate convergent fire, either from one or several batteries, against a fixed point, as easily by night as by day. So plausible did M. Chevalier's proposals appear to the Emperor, that a series of experiments was ordered to be undertaken in this direction as soon as the Toulon inquiry had ter-

minated, but in the meantime M. Chevalier's death has unfortunately occurred.

The production of military plans and maps is undertaken with the aid of photography at the French War Department, in pretty nearly the same manner as at Southampton; but there is one application of the art which appears to have been found exceedingly practical and successful, and which might with benefit be adopted into this country. The sealed patterns of articles of field equipment and other warlike necessaries are photographed on a small scale, and prints, with descriptions attached, distributed to Army Storekeepers, Commanding Officers, and other heads of departments. By the adoption of this course, when the supply of any particular store is necessary, the Officer demanding the article is incapable of making a mistake either in the nomenclature or description of the store required, thus preventing any loss of time occurring from incomplete or erroneous instructions. Mistakes and delays of this kind were formerly not of unfrequent occurrence in the correspondence between different branches of the War Department, and in demands received from colonial stations, but by this simple precaution the supplies of war material are now said to be greatly facilitated. In this country we have already an exceedingly complete catalogue prepared by the Controller of Stores at Woolwich, comprising every description of warlike implement, and it would certainly be a valuable addition to this volume if photographic illustrations of some of the more important articles were added in the form of an appendix.

Austria.—In the late German war no steps were taken by the Austrian Government to employ photography in the field. In the Military Geographical Institute, however, a numerous series of plans of the more important towns and fortresses of Prussia and Saxony were prepared by means of the photo-lithographic and ordinary photographic methods.

Belgium.—The Belgian War Office employs photography to a considerable extent in their Topographical Department, frequently using the process of printing by development, when copies are required without delay.

Holland.—In Holland there exists a photographic establishment in connection with the Ministry of War; it is stationed at the Hague, and is under the direction of Captain Van der Beeck. Photo-lithography has been used in this establishment to some extent, in preparing a collection of sketches, of artillery requisites. Chromo-lithographic maps are also prepared, as likewise other prints and designs for military purposes.

Prussia.—No official use was made by Prussia of photography during the late campaign, although it is mentioned on good authority that a short time previous to the breaking out of the war, the art had been employed by the Government for securing landscape views of Bohemia and other interesting localities. The formation of a photographic establishment has, however, just been decided upon, although no definite steps in regard to it have yet been taken.

Photography thus serves some very important purposes in connec-

tion with the pursuit of warfare, purposes which will, no doubt, become more extended from day to day as the art progresses towards perfection. That we shall soon witness this consummation there is every reason to believe, more especially when it is remembered that the radical improvements already effected, have all taken place within the space of thirty years; for although more than half a century has elapsed since a reflection of nature was first caught up and secured in the camera (May, 1816) by Nicéphore Niépce, a sub-Lieutenant in the French Army, no information on the subject of photography was made known until his surviving partner, Daguerre, published the Daguerreotype process in 1839. The art of photography, as it exists at present, is widely different from the processes of MM. Niépce and Daguerre. Those gentlemen made us acquainted with theoretical photography only, and it is due mainly to the exertions of Mr. Fox Talbot, Mr. Archer, and Sir John Herschel, that the art has reached its present advanced state and been rendered practicable to all the world. It would indeed be hard, then, if the Science of War could not derive some aid from this universal process, of which a soldier was the principal originator.